

15 MECHANICAL GAMING KEYBOARDS REVIEWED

CUSTOM PC

THE BEST-SELLING MAG FOR PC HARDWARE, OVERCLOCKING, GAMING & MODDING / ISSUE 152

50 TIPS TO BUILD A BETTER PC

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INSTALLATION

TWEAKING TIPS

BUYING ADVICE

PLUS

HOW TO
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WATER-COOLING
SYSTEM

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A LAPTOP

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86 50 tips for building a better PC

Whether you're new to the exciting world of PC building, or are already a veteran of the art, there's always room for learning from the experience of other fellow hobbyists.

For this issue of *Custom PC*, we asked ourselves what we wished we'd known when we first started building our own PCs, based on the knowledge we've accumulated over many years in the hobby, and decided to share the fruits of that experience with you.

The result is a colossal collection of 50 tips and tricks, covering hardware installation, tweaking tips, installing software and simple buying advice, to help you put together a better PC setup.

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P86



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Windows



BEN HARDWIDGE / FROM THE EDITOR

WHY AREN'T MORE PC ENTHUSIASTS CODING?

Ben Hardwidge has been enjoying coding with his newly repaired ZX Spectrum, and wonders when programming stopped being associated with fun

Brrrrr, bip. Brrrrrr, biddlybipbipsclawch. This month's soundtrack to my life is currently coming from my newly repaired Sinclair ZX Spectrum, as it loads some of my old games. I've swapped the RF output for a composite output, replaced the keyboard membrane and resoldered the power connector. It all works perfectly again, and I've even managed to get it to speed-load Manic Miner from an iPod in 25 seconds, thanks to some speeded-up audio and a small headphone amplifier.

It's been fun. The games look terrible, of course, but what really struck me about playing with my old Spectrum again is that it's a computer, rather than a games machine. On Pancake Day, I programmed in some BASIC code that a guy called Gary Plowman posted on Facebook, and it drew a stack of pancakes with a lemon. What's more, Usborne has also just made its old home computer books available for free download (<http://tinyurl.com/UsborneCoding>). I've been transported back to my childhood, when you didn't just buy games; you also typed in pages of code from books and magazines to make your own.

The end result was that you eventually had the knowledge to program your own games. I kept it up when we got our first PC, programming a text adventure with the GWBASIC software that came with it. The process was fun, educational and productive.

I know the market for text adventure games is rather diminished now, but we have amazingly powerful and flexible computers in our homes and so few of us learn to code with them. I know there's a big coding boom in the hobbyist and maker communities at the moment, and obviously lots of people know

how to code on the PC as well, but there now seems to be a divide between 'coders' and 'gamers', when most computer-owning kids in the 1980s did both.

I think a part of it comes down to the nature of old computers – just getting a game to work in DOS often required you to edit your autoexec.bat and config.sys files, to make sure you could get as much as possible into your 512KB or 640KB of base memory.

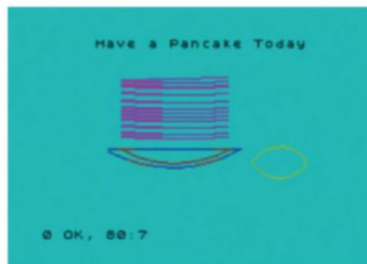
Just getting computers to work was a typing puzzle, not unlike a text adventure.

But we're now living in an age where a handheld ZX Spectrum emulator, the Vega+, smashes its Kickstarter target within three days. It's a Spectrum emulator without a keyboard – there's no way you can play text adventures on it, let alone code in BASIC – two of the main activities for Spectrum owners in the 1980s. Even retro computing is now all about quick-action

gaming, rather than puzzle solving and coding.

Windows PCs don't even come with BASIC programming software by default anymore. If you want to learn to code, you're expected to do it on a training course, rather than teaching yourself for fun. I'll admit that, apart from my recent Spectrum coding and some raw HTML here and there, I haven't programmed any substantial code for decades.

Coding shouldn't just be for Raspberry Pi owners and professional programmers – there are so many people with powerful and flexible PCs who could also be flexing their creative abilities. I'd love it if coding became fun for PC owners again. Are you a PC enthusiast who is also into coding for fun, or would you like to learn more? If so, I'd love to hear your thoughts. **GPC**



Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk [@custompcmag](https://twitter.com/custompcmag)



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RICHARD SWINBURNE / VIEW FROM TAIWAN

INTEL GIVETH AND INTEL TAKETH AWAY

By forcing the removal of base clock overclocking, Intel has alienated a core group of customers, argues Richard Swinburne

As soon as news broke that Supermicro had made overclocking possible on Intel's non-K series, sixth-generation (Skylake) processors via the base clock, the floodgates of BIOS updates opened and all motherboard makers enabled the same feature. Highly affordable Core i3 chips were getting excellent 40 per cent overclocks and, given the stagnation of PC sales, you'd think Intel wouldn't mind – a sale is a sale, right?

But no. In an act of anti-consumer, bean-counter cynicism, Intel has decided to take away this unofficial feature and replace it with, yep, nothing. There's no Pentium Anniversary Edition or Core i3 K-series chip to plug the obvious gap in the market, just kthxbye.

I'm mainly firing my forked tongue at the financial teams, because it's not as if overclocking non K-series chips is seriously hurting Intel's bottom line either – a lot of K-series chips are still being sold hand over fist, as many overclockers prefer the easy option of just increasing the multiplier. That's fair enough; multiplier overclocking is less of a faff than base clock overclocking, and the result is similar. I'd argue that anyone who bought Core i3 chips in order to overclock them would never have considered an upgrade if they had needed to fork out for a Core i5-6600K, so effectively Intel has gained more sales.

To make matters worse, in spitefully forcing through an updated microcode in the latest BIOS updates, any future security holes that are discovered won't be patched for this section of the Skylake customers. Many of these people will prefer to take the risk than lose their overclock, and who can blame them?

There are arguments against overclocking non-K series CPUs, but all of them ring hollow. 'These chips aren't designed for

overclocking' is bogus, as these CPUs are no more likely to fail than K-series chips and, credit where it's due, Intel offers industry-leading chip quality, so RMAs are unlikely.

Another argument is that 'maybe people buy cheap, unsuitable motherboards to overclock these cheap chips,' to which I reply 'so what?' A modern motherboard should have over-current, power and temperature protection built into it in order to prevent serious failure, and *any* board that doesn't have these essential safety features isn't worth your money. Besides, as we found last month (see Issue 151, p84), you can get a perfectly capable motherboard for the job for just over £100.

Then there's 'if a game performs well with an overclocked Core i3, why would you buy a K-series Core i5?' Of course, DirectX12 should unlock more multi-threaded CPU performance, as its load balancing and threading engine is massively different from that of DirectX11. If

there's still no advantage then Intel needs to work harder with game developers to improve threading in games to justify its own price structure of physical cores over virtual ones. Finally, there's the comical 'base clock overclocking is more difficult' argument. No, it's more *fun*. To balance fine-tuning a multiplier, base clock and half a dozen different voltages is time consuming, but it provides the great learning experience and deep sense of achievement that's driven enthusiasts for years.

Base clock overclocking offered Intel an ideal opportunity to endear itself to budget-conscious enthusiasts and potential upgraders. Unfortunately, with little strong competition, Intel will continue to force through the removal of such unofficial features. We need a strong AMD comeback more than ever! **GPG**

Many people will prefer to take the risk than lose their overclock

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

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ROCCAT's all new Kova gaming mouse is the high speed gaming tool for players who value execution over flash. Optimized for both left and right-hand use, with a simple, sleek, high-performance design, the Kova provides a fine-tuned sports car vibe in the body of an impressively engineered mouse. Smart Cast technology provides twice the advantage, with an optimally placed button layout that doubles up on your standard mouse 1 and mouse 2 functions.

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Letters

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Pushmi-pullyu

I've been reading Issue 146, and I have a question about the Skylake build. In step 6 (titled 'fit fans on cooler') of the build guide, it says: 'Most all-in-one liquid coolers require you to fit their fans, so go ahead and do this now before you install the radiator. In our case, we'll be fitting the fan from the top, screwing the radiator into position at the same time.'

The supporting picture shows the fan being installed on the Kraken in a push configuration. However, steps 8 and 9 show the radiator being installed to the top of the case, and the fan being installed outside the case, in the roof mount, in a pull configuration. It's slightly confusing. To me, it means that step 6 isn't required, as you would install the fan in step 9. Did I miss something? Also, I note that NZXT recommends a push configuration for its Kraken coolers, but I've seen on Linus tips that a radiator with a fan in a push configuration gets pretty crammed with dust – does using a pull configuration affect the cooling of the Kraken?

FRASER

Antony: Hi Fraser. Thinking back, I think we may have found that fitting both the radiator and cooler in the Cosmos case below the fan mount wasn't possible, and similarly, it wasn't possible to mount just the radiator above it either. As a result, we opted for a pull configuration, with the fan above the fan mount and the radiator below it in this particular instance. There's actually very little, if any, difference between push and pull configurations in terms of performance – push may be very slightly better, as the highest static pressure is directly behind the fan, which can be useful for pushing the air through the radiator, but in my



There's little between push and pull configurations in terms of performance

experience the difference is negligible.

However, you're right that in this case, step 6 is indeed redundant in our feature – I think we may have discovered the installation issue after we took the photo and wrote that bit of the guide, so I'm sorry about that! In most cases, though, you would normally fit the fans to the radiator first and then install it to the case – it's easier. As for the dust issue – I haven't seen the Linus video on this topic, but if you're mounting a radiator in the roof, you should always have it exhausting air. There are rarely any dust filters in that part of the case, so drawing air inwards will result in dust clogs.

CPU for a gaming HTPC

I plan to build a new living room PC, which is going to be very small, very quiet and have an integrated graphics system that's capable of playing 4K video on my UHD screen. That's simple enough. However, I'm going to purchase a motherboard with Thunderbolt III over USB-type C and then, when we want to play games (which we do using Xbox controllers), I'll power on a Razer Core (or similar) external GPU system, which will be populated with a dedicated graphics card – probably a GeForce GTX 980 Ti. Again, that's not too complex.

The sticking point is the CPU though. If it were only for HTPC use then I would just buy a low-powered processor, such as the i3-6100T; if it were just for gaming, I would buy a much more potent CPU, as the energy consumption, heat and noise wouldn't matter, since it would only be powered on for relatively brief periods. I need to compromise, but although the external GPU system is easy, I can't figure out the actual base requirement for UHD gaming in terms of the CPU power.

CHRIS JONES

Ben: There are a few factors to consider here, Chris. The first of which is that most games respond more to clock frequency than to multiple cores. For starters, I would rule out any LGA2011



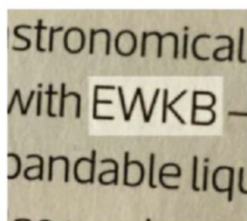
Noctua's L9i is great for HTPC builds

PEDANTS' PARADISE

Typotastic

Being very pedantic, I noticed on p20 of Issue 151 that you mention the Asus Maximus VIII Formula supports DDR3 RAM up to 3733MHz, when of course it supports DDR4 memory. I noticed on p20 of the same issue that you refer to EWKB, when, it is of course EKWB.

DOMINIC MOASS



Developers need to do more, especially with family gaming

gear – you simply won't need more than four cores for what you're doing, even at 4K. That said, these days, we're seeing definite benefits to having four cores in new games, and at 4K (where the GPU is pushed right to its limit), you want all the performance you can get.

The key to your system will be balancing gaming performance with thermal demands so you can keep down the fan noise. We often recommend cheaper dual-core CPUs for budget 1080p gaming, but these dual-core CPUs really need to be overclocked to be worth their while for gaming, and that will push up the temperature.

For your purposes, I'd go with a Core i5 Skylake chip – the non K-series 6600 (you won't be overclocking it, after all) has a TDP of 65W, it Turbo Boosts to 3.9GHz and its four cores will give you a benefit in newer games that make more use of multi-threading. That 65W TDP might be more than double the 35W of the Core i3 6100T, but Noctua's quiet, low-profile L9i CPU cooler will still easily be able to handle it – just make sure your system has some quiet low-speed fans and plenty of vents to enable airflow.



Cooperative gaming with kids

Hi beautiful PC mag, I read Rick Lane's 'Jolly cooperation' column about cooperative gaming with interest (Issue 151, p73), and I agree that developers need to do more, especially with family gaming. My six-year-old has an MSI GE72 2QC gaming laptop, and has just discovered the wonders of FIFA 15. I set up an Origin account for him and, due to his date of birth, it



Twitter highlights

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Pc_Shed Hooray! 100 Million points milestone reached in 57 days folding for @CustomPCMag & @bittech FT. Need more GPU's!!



Ben: Wow, that's some seriously powerful computing in a short space of time – good work – glad to have you on our Folding@home team! We've interviewed Sergio Rodrigues (PcShedTV) about his Folding@home setup in this issue on p112.

MeekDope_ How many gigabytes of VRAM does the AMD A10-7860 APU's dedicated GPU have?

Ben: AMD's APUs share your system memory, rather than having their own dedicated memory. However, you won't need to share loads of memory with the GPU for the resolutions and settings at which these integrated GPUs are capable of running games. The bigger issue is the speed of your memory – officially, AMD's A10 7860 supports 2133MHz memory, but some motherboards will enable you to run it with 2400MHz memory, which gives you a solid boost of games. Also, make sure you run your memory in dual-channel mode, as single-channel RAM dramatically drops gaming performance if you're using the integrated GPU in an AMD APU – see tip 43 on p92.






created a very limited child account. This account only allows you to add and play games in your library, which is excellent to a point. However, if I want to play a cooperative FIFA match with him, I can't do it because the child account doesn't allow anyone to be added as a friend – not even a parent.

I reckon EA has taken its child account policy a bit too far. On the flip side, my two sons and I can all

Limits on Origin's child accounts mean FIFA 15 can't be played cooperatively

play Next Car Game across the LAN, and have a really good demolishing derby session, because the game allows it. I already govern the kids' computer usage with Microsoft Family, which is brilliant. However, I think EA's child account policies in Origin definitely need improving.

JULIAN VICARI

Ben: That's an interesting point, Julian, which I hadn't considered. Cooperative gaming is great for families, but you lose that fun if your child's Origin account won't allow cooperative play. You can see why it's happened, but it needs a more nuanced approach. **GPG**

WHEN'S THE NEXT MAG COMING OUT?

Issue 153 of Custom PC will be on sale on Thursday, 14 April, with subscribers receiving it a few days beforehand.

APRIL
14

Send your feedback and correspondence to letters@custompcmag.org.uk



TRACY KING / SCEPTICAL ANALYSIS

A SHOT IN THE DARK

Our definition of violent content has radically changed since the early 1990s, argues Tracy King

It isn't every day that a research paper lands on my desk that's been written by friends, but I find myself in the interesting position of writing a column about the recent work of scientist Pete Etchells, who I know and respect. Bit awkward.

You may have heard of the paper, or at least seen some of the headlines. It was on the Reddit front page for a while, and has attracted a lot of interest. 'Is there an association between video games and aggression?' asks The Guardian in a piece written by Etchells. The gist is that there was a longitudinal study (one that lasts years) undertaken by University of Bristol to 'chart the health' and lifestyles of 14,500 families in the Avon area. It started in the early 1990s and now we have the results, which is where Etchells and collaborators got their data. So far, so good. They wanted to see if kids of the 1990s who played 'violent' video games did indeed turn out to be psychopathic school shooters, as so many fearmongers insist.

It's a noble pursuit and a question everyone wants answered definitively. But as I often say, knowing isn't proving, and Etchells and his team wanted better evidence one way or another. The difficulty with this data set, however, is that the way the question was worded 20 years ago was a bit rubbish. Instead of asking about the content of games, the original researchers listed a bunch of genres that quickly became outdated. The closest genre to 'violent' that Etchells could find was 'shoot-em-ups'. Hands up if you laughed and then sort of winced a bit.

'We had to make an assumption that if kids were playing games such as GoldenEye 64, they would have ticked the shoot-em-up box. It's by no means perfect, but it's the best

we could do with the data,' says Etchells. Hmm, I don't particularly like that assumption, partly because 'shoot-em-ups' historically included games such as Space Invaders, which isn't what anyone means when they say 'violent,' and partly because we don't know the researchers' definition of shoot-em-ups, let alone what the kids in the study thought.

I had an honest chat with Etchells about it, and he agrees the question was 'a crude measure' but adds that 'games from around that time are very different to now, so our study doesn't have anything to say about the effects of playing modern console shooters or mobile games. That isn't to say that our study isn't useful; just that we have to be careful about making overly generalised claims about what the results mean.' And indeed, the press release says in big letters at the top that 'this study does NOT show that videogames cause aggression,' which is refreshing to see.

And yes, something is better than nothing. However, while it's interesting (rather than useful) to know that kids in the 1990s who played games they themselves classified as 'shoot-em-ups' did have a slightly increased risk of developing a conduct disorder at age 15, perhaps the best lesson from this episode is that trying to gather data about video games by genre is a mistake. I would rather see 'violent' video games studied by content: Is there onscreen blood? Can you permanently kill a NPC? Are you fighting human characters? And so on. Of course, games and our definition of 'violent' content changes rapidly, so maybe longitudinal studies on gamers will always be flawed and we need an entirely new approach. Now excuse me, I'm off to shoot up some ems. **GFC**

The closest genre to 'violent' that Etchells could find was 'shoot-em-ups'

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming [@tkingdoll](#)

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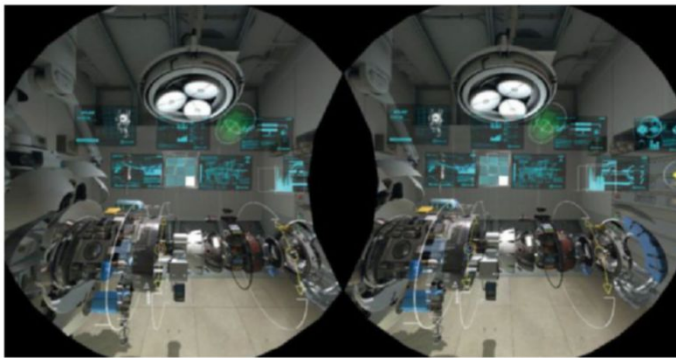
gmaster.iiyama.com

Incoming

We take a look at the latest newly announced products

Corsair launches VOID Surround headset

Corsair has released a new surround-sound headset designed for PC gaming. The new VOID Surround has a standard 3.5mm jack output for connecting to consoles, but comes with a USB Dolby Headphone 7.1 adaptor for connecting to a Windows PC. According to Corsair, the VOID Surround is 'built from the ground up to redefine comfort and enable marathon gaming sessions', promising 'a revolutionary new ear cup shape and top of the line microfibre fabrics and memory foam'. The Surround also has a cast aluminium construction, and features large 50mm neodymium drivers, as well as a unidirectional noise-cancelling microphone. The VOID Surround is available now for £80 inc VAT from www.corsair.com



Valve releases VR test

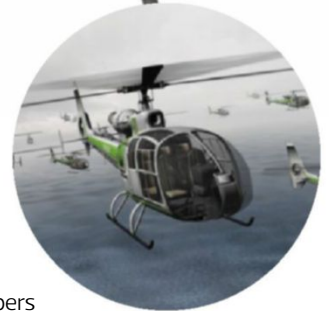
If you're getting excited about VR gaming, Valve has released a test for your system to see if it has the power required to run games on the new Vive SteamVR system it's developed with HTC. SteamVR Performance Test is free to download from <http://store.steampowered.com/app/323910/>, and runs a two-minute sequence from Valve's Aperture Robot Repair VR demo.

According to Valve, the object of the test is to gauge whether your system can run VR content at 90fps. If your machine isn't VR-ready, it will tell you whether it's your CPU, GPU or both that's holding you back. We ran the test on a Core i7-3770K system with a GeForce GTX 980, which passed the test for high-fidelity VR, showing that you won't be limited by older CPUs if they're powerful enough, as long as you have a decent GPU.



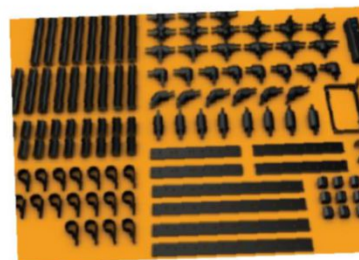
Vulkan API gets public release

Non-profit API consortium The Khronos Group has announced public availability of the new Vulkan graphics and GPU-compute API. Originally based on AMD's Mantle API, Vulkan is an open low-level graphics API, aiming to give game developers closer access to GPU resources, while using the CPU less than OpenGL and limiting software overheads. Vulkan also aims to make better use of multiple CPU cores than OpenGL. In simple terms, you can think of it as the OpenGL equivalent of DirectX 12. Unlike Mantle, however, Vulkan has driver support from both AMD and Nvidia, as well as Intel. See www.khronos.org/vulkan for more information.



Aerocool launches DIY case kit

Aerocool has announced a new kit that effectively enables you to build your own PC case. Like a large Meccano set, the Aerocool Dream Box kit features several parts that you can fit together to make your own chassis. The 118-part kit includes a PSU bracket, some aluminium pipe, several joints, an I/O unit, and various other parts and brackets. However, there are no solid panels, so you're basically building a frame. Aerocool says the kit can also be used for



many other construction projects, with examples on its website including a coat stand, a cup holder and, bizarrely, a wild boar model. You can find out more information about the Aerocool Dream Box at <http://dreambox.com.tw>



VENOM

BLACKBOOK

15



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Reviews

Our in-depth analysis of the latest PC hardware



Reviewed this month

SilverStone SST-TD02-Slim p19 / Cooler Master Hyper TX3i and Hyper 212X p20 /
NZXT Manta p22 / MSI Z170A Gaming Pro Carbon p26 / Gigabyte Z170-Gaming K3 p28 /
CyberPower Fangbook 4 SK-X17 p30 / Custom kit p32

CPU COOLER

SilverStone SST-TD02-Slim / **£68** inc VATSUPPLIER www.scan.co.uk

SilverStone's new TD02-Slim sports a similar waterblock and design to the company's other all-in-one (AIO) liquid coolers but, as its name suggests, its fans are half-height 120mm models that are just 15mm thick, instead of the usual 25mm. The radiator is only 22mm thick too – a good 8mm thinner than many other half-height radiators. The total thickness of just 37mm is around 20mm slimmer than most double 120mm AIO liquid coolers.

Not many cases that need such a slim cooler, but some motherboard and case combinations might benefit due to large heatsinks restricting clearance, plus it may be possible to mount the radiator or fans between the case and a plastic shroud. There's obviously less cooling power, though, as

the radiator has a reduced capacity, plus the fans won't be able to shift as much air, even at their rated 2,200rpm speed. Thankfully, they're both equipped with 4-pin PWM cables, so while the cooler lacks software control, most motherboards can tune them down.

The pump section mounts in a fairly simple way on LGA2011 motherboards, using four CPU socket pins plus sprung

thumbscrews to secure its mounting plate. Fitting it to other systems is a little trickier, though, as you need to pass pins through a backplate before attaching a second set of pins the other side. You then secure the cooler using the same sprung screws. Plenty of thermal paste is included, so you'll be able to mount it three or four times before running out. However, the radiator is very easy to install, thanks to its light weight and small size. It has the usual 15mm fan spacing and screws are included for a multitude of installation scenarios too.

Performance-wise, the SST-TD02-Slim struggled to keep up with the other AIO liquid coolers on test, with even the single 120mm-fan Corsair H75 managing similar results in our LGA2011 test system. It struggled most in our LGA1150 system, where it was 6°C warmer than the H75, and a

significant 13°C adrift of the Corsair H105. At full speed, the fans made quite a racket too. Tuning them down in the motherboard's EFI to a quiet profile made the noise less intrusive under low loads, but they were still audible.

The SilverStone SST-TD02-Slim doesn't offer chart-topping cooling or low noise. In fact, it isn't much better than many good air coolers, with smaller AIO liquid coolers performing similarly. Thankfully, at less than £70, it's much cheaper than most other double 120mm-fan radiator coolers – Corsair's H105, for example,

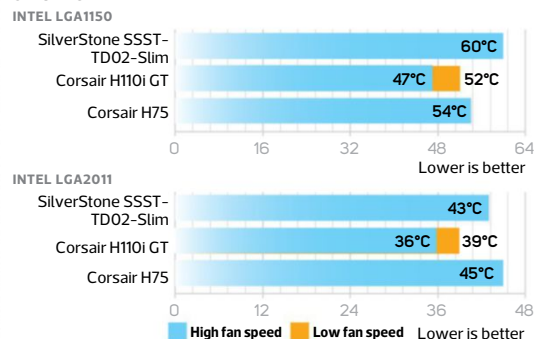
costs nearly £100. However, unless you specifically need a super-slim cooler, many air coolers offer lower noise and similar cooling abilities, while Corsair's H75 is only slightly thicker and performs better on LGA115x systems.

ANTONY LEATHER

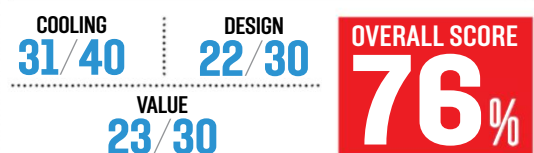


Its fans are half-height 120mm models that are just 15mm thick

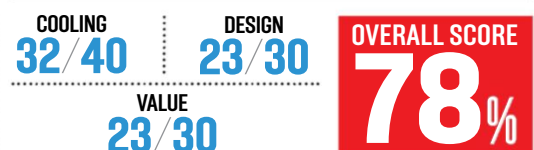
CPU LOAD DELTA T



LGA115x



LGA2011



VERDICT

A very slim liquid cooling setup for a good price, but its cooling ability isn't great.

/SPECIFICATIONS

Compatibility Intel: LGA2011, LGA2011-v3, LGA115x, LGA1366, LGA775; AMD: Socket AM3+/3+, AM2+/2+, FM2+/2+, FM1

Radiator size with fans (mm) 273 x 120 x 37 (W x D x H)

Fans 2 x 120mm

Stated noise Up to 27dB(A)

CPU COOLERS

Cooler Master Hyper TX3i / £22 inc VAT and Hyper 212X / £30 inc VAT

SUPPLIER www.scan.co.uk

With a long-standing history of making good CPU coolers, Cooler Master has been hard at work updating some of its aging air coolers, and two of the results are the new Hyper TX3i and Hyper 212X. Both these coolers are revamped models of the TX3 and 212 EVO respectively – two of Cooler Master's budget air coolers.

The TX3i offers manufacturing improvements over the older TX3 and also sees it ditching AMD socket compatibility, restricting itself to Intel's LGA115x and LGA775 CPU sockets only. Meanwhile, the 212X replaces the 212 Evo, again with performance-enhancing manufacturing improvements, but it retains support for all major CPU sockets.

Costing £22 and £30 inc VAT respectively, the TX3i and 212X are both competitively priced, although the latter costs a few quid more than our current Elite-listed 120mm-fan air cooler, the SilverStone Argon AR01, which currently retails for £26 inc VAT.

Let's start with the 212X, which uses a single 120mm fan but dispenses with the usual annoying metal clips, instead featuring pre-installed mounts that

enable the fan to be quickly snapped onto the heatsink. Additional mounts are included that enable you to mount a second fan too. The included fan sports redesigned fan blades that encourage vortices, which Cooler Master claims will help to boost airflow without increasing noise.

The heatsink features aluminium blades and a healthy set of five 6mm heatpipes that make direct contact with the CPU. Measuring 158mm tall, the Hyper 212X is relatively compact, making it ideal for cases with a 160mm CPU cooler

height limit, such as NZXT's Manta (see p22). Installation is a tad fiddly, though, mainly because of the universal, cross-shaped socket mount. It's adjustable in order to cater for both Intel and AMD CPU sockets, but it can be tricky to align with the mounting pins. It straddles the heatsink's contact plate, but it's difficult to hold it in place and mount the cooler at the same time.

The TX3i, meanwhile, costs just £22 inc VAT and uses push-clips to mount on your motherboard's CPU socket. The trick with these clips is to rotate them all fully clockwise before you install them – they then lock into place with a generous amount of pressure. As a result, though, it only supports Intel's LGA775 and LGA115x sockets, but it's much less of a pain to install than the 212X.

It has three heatpipes of the 6mm variety – again making direct contact with the CPU. It also offers a single 92mm fan and, like the 212X, it



Cooler Master Hyper TX3i

includes mounts for a second fan too. It's extremely compact, measuring just 136mm tall, and it does a good job of staying well away from your motherboard's memory slots and heatsinks. There's no TDP limit mentioned either, so we had no qualms about strapping it to our overclocked Core i7-4790K CPU for testing.

Performance

Both coolers exhibited fairly different noise profiles. The smaller TX3i produced a fairly significant airflow noise at full load, which was certainly noticeable above the din of the rest of the system.

Thankfully, there was no coarse tone or whine along with it and, in PWM mode, it was relatively quiet at lower speeds. The larger 212X produced less noise at full speed, but it exhibited a low-level hum at most fan speeds, which was more noticeable than the airflow noise.

The 212X managed a delta T of 61°C in our LGA1150 system, which is 2°C warmer than the SilverStone AR01, and a fair amount less potent than some larger air coolers, such



The TX3i uses push-clips to mount on your motherboard's CPU socket

Measuring
158mm tall, the
Hyper 212X is
relatively compact

HYPER TX3i / SPECIFICATIONS

Compatibility Intel: LGA115x, LGA775

Size with fans (mm) 92 x 79 x 136 (W x D x H)

Fans 1 x 92mm

Stated noise Up to 30dB(A)

HYPER 212X / SPECIFICATIONS

Compatibility Intel: LGA2011, LGA2011-v3, LGA115x, LGA1366, LGA775; AMD: Socket AM3/3+ AM2/2+ FM2/2+, FM1

Size with fans (mm) 120 x 79 x 158 (W x D x H)

Fans 1 x 120mm

Stated noise Up to 36dB(A)



The 212X's heatsink features a healthy set of five 6mm heatpipes

as the Noctua NH-D15, which was quieter and managed a delta T of 51°C. We've replaced our LGA2011 motherboard since our last CPU cooler Labs, so the results from that test aren't comparable here, but we've tested a few coolers on the new motherboard to get some comparison results.

In our new test rig, the 212X's delta T of 47°C was enough to come within 2°C of Corsair's H75 all-in-one liquid cooler, and it also bettered Alpenföhn's Atlas cooler by 4°C. Sadly, switching to PWM mode and limiting the fan profile to reduce the noise under load didn't work out too well. In our LGA2011 system, the delta T rocketed from 47°C to over 65°C in less than a minute in this PWM mode, so it's clear that in most scenarios, you'll need the cooler running flat-out if your CPU is overclocked.

The TX3i only has one result from our test systems due to its limited compatibility, so we've only tested it with our overclocked Core i7-4790K. In this test rig, it managed a delta T of 67°C, which is 6°C warmer than the 212X and 8°C warmer than the result from our Elite-listed SilverStone AR01, which only costs £4 more.

Conclusion

The Hyper 212X's low level hum may be an issue for otherwise quiet systems, but it performed well, if not remarkably, in both our test systems. It was some way behind the SilverStone AR01 in our LGA1150 system, though,



Cooler Master Hyper 212X

so the AR01 earns its right to stay as our Elite-listed LGA115x air cooler in this price league. The 212X came within a couple of degrees of the Corsair H75's result in our LGA2011 system, though, albeit with more noise, so it's a good choice for a budget cooler to deal with moderately overclocked LGA2011 CPUs.

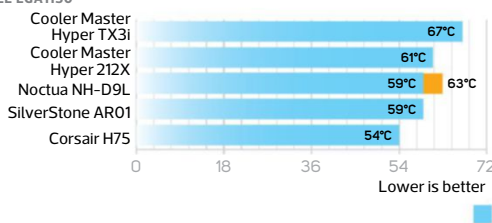
Meanwhile, the Hyper TX3i has a simple mounting mechanism, and it's relatively quiet once its fan winds down too. However, it isn't going to cope with a massively overclocked CPU, as the core temperature was approaching 90°C even with our 4.4GHz Core i7-4790K.

If you have the room for it then SilverStone's AR01 is a superior cooler for only a little more money. However, if you're running your CPU at stock speed, or are only aiming for a small overclock then it's a reasonably capable compact cooler if you can't run to the cost of Noctua's NH-D9L.

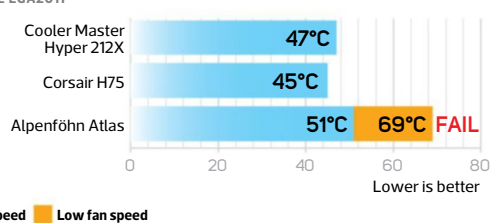
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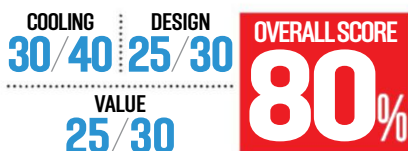
INTEL LGA1150



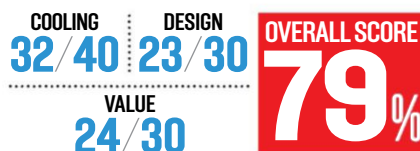
INTEL LGA2011



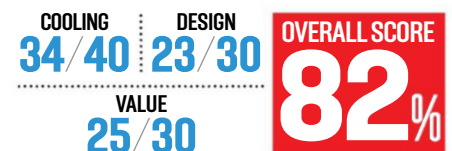
COOLER MASTER HYPER TX3i/LGA115X



COOLER MASTER HYPER 212X/LGA115X



COOLER MASTER HYPER 212X/LGA2011



MINI-ITX CASE

NZXT Manta / **£110** inc VATSUPPLIER www.scan.co.uk / MODEL NUMBER CA-MANTW-M2

The Manta isn't quite what we expected from NZXT's first foray into mini-ITX for a number of years, but it's still very interesting, especially if you like all-in-one liquid coolers or water cooling. The exterior is rather oversized and has bulbous, curved front, side and roof panels. This design swells the case's already hefty dimensions to levels that would actually swallow many micro-ATX cases quite comfortably; SilverStone's PS09, Corsair's 350D and Phanteks' Enthoo Evolv are all the same size or smaller, and house larger motherboards.

That isn't to say the Manta is unattractive though. It isn't just a big box, and its distinctive appearance looks great, especially in the black and red colour option. It's impeccably well made too. The side panels are weighty and made from several layers of metal and plastic.

They're also totally rattle-free, and they offer a good deal of noise insulation.

Meanwhile, the front and roof panels pop off to reveal a host of large fan mounts, and there's a good-sized window to give you a view of your hardware too. Move to the top and you'll find the front-panel connectors, including USB 3 ports, audio jacks and

a power button. On the bottom, you'll find two large feet with rubber grips, and at the rear is a removable PSU dust filter.

Cooling is a major focus for the Manta, and NZXT has made sure it supports its range of Kraken all-in-one liquid coolers (even the monstrous X61 fits inside with plenty of room) and indeed custom water-cooling systems too. There's a large reservoir mount next to the motherboard tray, and plenty of room on the PSU cover to mount a

separate pump if needed. Both the roof and front fan mounts also support two 120mm or 140mm fans and double 120mm or 140mm radiators – quite a feat for any case of this size. There's a large dust filter in the front too, with a vacant space behind it that's large enough for two 120mm fans but, as it stands, the included front fans are installed on the other side of the fan mount, inside the case. Alternatively, you can fit a half-height radiator in this area too.

By moving the fans to the front of the fan mount, however, you get 70mm of clearance for up to a double 120mm or 140mm-fan radiator behind it, while the roof is limited to a single row of fans and a similar half-height radiator. Even so, the ability to fit two double 140mm-radiators in a mini-ITX chassis is an impressive achievement, although it's unlikely any mini-ITX setup would require that level of cooling. Airflow appears to be rather restricted too – much like the Phanteks Evolv ITX, the Manta only has small side vents for both the front and roof fans,



which isn't an ideal setup for dealing efficiently with the airflow from two 140mm fans or large radiators.

There's plenty of room inside the case as well, but not as much as you would expect, given the size of the exterior. There's just enough space for a motherboard and dual-slot graphics card, although CPU coolers are limited to 160mm in height. There's a dedicated 3.5in drive mount in the base that uses rubber washers, plus another drive mount that also supports 2.5in drives. There are two further 2.5in mounts that are well placed and easy to use, sitting vertically next to the reservoir mount adjacent to the motherboard, although they're not too free.

The interior design works brilliantly – the dust filters are easy to remove and cable routing is excellent. As a bonus, cables can be hidden under the PSU cover as well as cable-tied to the rear of the motherboard tray. The end result is a great-looking PC case with the attractive additions of an illuminated rear I/O panel and NZXT logo on the side of the PSU cover – you can toggle the lighting so that they're both on or off, or with just one of them illuminated.

Performance

As we suspected, the lack of decent vents did hamper the Manta's airflow a little, mainly on the CPU, with a delta T that was 5–6°C adrift of the better results we've seen. Not surprisingly, it performed similarly to the Phanteks Evolv ITX in this test, with the two cases sporting similar out-of-the-box cooling – that isn't a major problem, though, as these cases are geared more towards small tower coolers and all-in-one liquid coolers than our low-profile mini-ITX test cooler. However, thanks to two 120mm fans being included in the front, as well as the vents in the PSU cover, the GPU cooling fared a little better, with a GPU delta T of 48°C. That result still isn't as good as those of the Fractal Design Core 500 or Corsair Obsidian 250D, but it offers better stock GPU cooling than the Phanteks case. The fans are very quiet too, helped by the hefty construction that seals the noise inside the case – any distracting noise will come from your components, rather than this case.

The dust filters are easy to remove and cable routing is excellent

/SPECIFICATIONS

Dimensions (mm) 245 x 450 x 426 (W x D x H)

Material Steel, plastic

Available colours Black, black/red, white/black

Weight 7.2kg

Front panel Power, 2 x USB 3, stereo, mic

Drive bays 1 x 3.5in, 1 x 3.5in/2.5in, 2 x 2.5in

Form factor(s) Mini-ITX

Cooling 2 x 120mm/140mm roof fan mounts (fans not included), 2 x 120/140mm front fan mounts (2 x 140mm fans included), 1 x 120mm rear fan mount (fan included)

CPU cooler clearance 160mm

Maximum graphics card length 363mm



1
A large reservoir mount is next to the motherboard tray

2
Cables can be hidden under the PSU cover, which has an illuminated NZXT logo

3
The two 2.5in mounts on the right are well placed and easy to use



Conclusion

NZXT's Manta is a new and exciting mini-ITX case with plenty of design aspects and features we grew to love. It's incredibly well made and solid, and it makes building a system a hassle-free and rewarding experience. It's adept at being a home for air-cooled or water-cooled systems, with particularly good support for the latter. It looks great too, especially if you get a two-tone colour version.

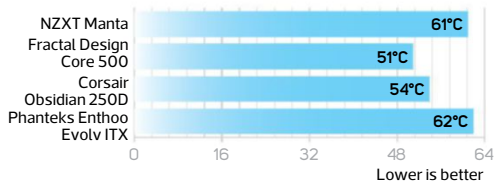
However, there are two glaring issues. Firstly, it's just too big for a mini-ITX case. You can fit the same hardware, albeit with slightly scaled-down water-cooling support, in much smaller cases such as Fractal Design's Core 500. Its curved

design adds even more bulk to its already hefty dimensions too. A mini-ITX case should have an advantage in size over its micro-ATX counterparts, even if you're factoring in water-cooling support. Secondly, the price of £110 inc VAT is huge for a mini-ITX case – more than much of the competition and it certainly isn't as good looking as InWin's similarly priced glass-clad 901 either.

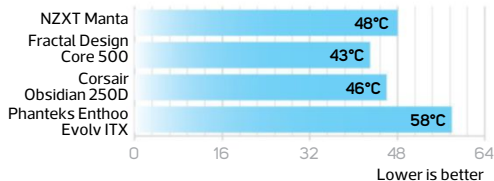
However, while it isn't the top scorer in terms of looks, out-of-the-box cooling or value for money, and as a result, can't win an award, it's still a well-designed and constructed, if enormous, mini-ITX case.

ANTONY LEATHER

CPU LOAD DELTA T



GPU LOAD DELTA T



COOLING
23/30

FEATURES
18/20

DESIGN
27/30

VALUE
14/20

OVERALL SCORE
82%

VERDICT

The Manta oozes quality and refinement, and boasts excellent water-cooling support, but its size and price are excessive for a mini-ITX case.



Performance without compromise



Spectre Lite

- AMD FX-4300
- ASUS® M5A97 R2.0
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 950
- 1TB Hard Drive
- Corsair 350W PSU
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- ASUS® Maximus VIII Hero
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- ASUS® Z170-E
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ATX MOTHERBOARD

MSI Z170A Gaming Pro Carbon / **£120** inc VATSUPPLIER www.box.co.uk

If you fancy having RGB lighting on your motherboard, but Asus' lighting-equipped offerings, such as the Maximus VIII Formula or Hero, aren't quite in your price range, then MSI's new Z170A Gaming Pro Carbon might be just the ticket, retailing at a tempting price of £120 inc VAT.

Like MSI's Z170A XPower Gaming Titanium, the Z170A Gaming Pro Carbon has chrome-plated PCI-E slots, but it also sports a black PCB, black heatsinks and carbon fibre detailing. There's essentially no colour on the PCB, which makes it easier to colour-match it with the rest of your hardware, something you can't achieve with the likes of Gigabyte's otherwise excellent Z170MX-Gaming 5, with its obvious red details.

RGB lighting can be useful when it comes to colour matching too. The Z170A Gaming Pro Carbon's lighting system isn't as extensive as that on the Maximus VIII Formula, though, and extends to just some printed patterns next to the 24-pin ATX power connector. The LEDs are underneath the board, and dish out plenty of light, although the effect isn't particularly even or vivid when shining through these patterns – the main effect is light bouncing off your motherboard tray.

The lighting is controlled using Windows-based software, rather than the EFI, and you can select a specific colour using an RGB palette and apply several effects. The colours aren't quite as accurate as those on some of Asus' motherboards, or those available from NZXT's Hue+ RGB lighting system, but they definitely add some pizzazz to an unlit system.

MSI's included software also deserves praise. The Gaming App, which controls the lighting, also provides access to one-click performance modes, such as Gaming and Silent, with the latter cutting back fan speeds.

Meanwhile, Gaming Hotkey and Mouse Master enable you to program your keyboard and mouse buttons respectively, as well as record and execute macros. Its Command Center software is particularly good too, offering easy access to a number of overclocking options from the desktop, including the ability to tap into MSI's excellent fan control suite. We had no problem overclocking from within Windows with this software, so if you're a beginner looking for a board to learn the dark arts of overclocking, the Z170A Gaming Pro Carbon is a good choice.

Despite its reasonable price tag, MSI has managed to shoehorn full USB 3.1 support into the package, with single Type-A and Type-C connectors on the rear I/O panel. Sadly, there aren't many

on-board overclocking tools though – power, reset or clear-CMOS buttons are absent and there's no LED POST code display either, although very few sub £140 boards offer these features anyway. Layout is generally good, apart from two niggles. The first is that the 8-pin EPS 12V connector and CPU fan header are mounted very close to the heatsink at the top of the board, which makes it awkward to install their corresponding connectors. Secondly, the heatsinks around the CPU socket are shaped in a way that makes it tricky to mount some all-in-one liquid-cooler blocks, such as the one with our Corsair H80i GT test cooler.

These complaints are far from deal breakers though. You also get a 4x PCI-E 3 M.2 slot, which is sensibly positioned above the primary 16x slot. This M.2 slot sits behind a 1x PCI-E slot, but access to your M.2 SSD will be unhindered if you don't use this PCI-E slot, and there three other 1x PCI-E slots available too. There are also three 16x PCI-E slots, although the third is limited to 4x mode, with the two chrome-plated slots offering 16x mode in single-GPU configurations, or dual 8x mode in SLI or CrossFire configurations. The top two 16x slots are sensibly spaced too – offering loads of room for big graphics card coolers.

Performance

With a total system score of 135,068 at stock speed in our RealBench 2015 suite, the Z170A Gaming Pro Carbon is above average in our score table, bettering Asus' similarly



/SPECIFICATIONS

Chipset Intel Z170**CPU socket** Intel LGA1151**Memory support** 4 slots: max 64GB DDR3 (up to 3600MHz)**Expansion slots** Three 16x PCI-E 3, four 1x PCI-E 3**Sound** Realtek ALC1150**Networking** Intel I219-V Gigabit LAN**Overclocking** Base clock 98–341MHz, CPU multiplier 8–80x; max voltages, CPU 1.55V, RAM 2.2V**Ports** 6 x SATA 6Gbps (Z170), 1x M.2, 1x USB 3.1 Type-A, 1x USB 3.1 Type-C, 2 x USB 3, 4 x USB 2, 1x LAN, 8-channel surround audio out, line in, mic, optical S/PDIF out, 1x HDMI 1.4, 1x DVI-D, 1x PS2**Dimensions (mm)** 305 x 244

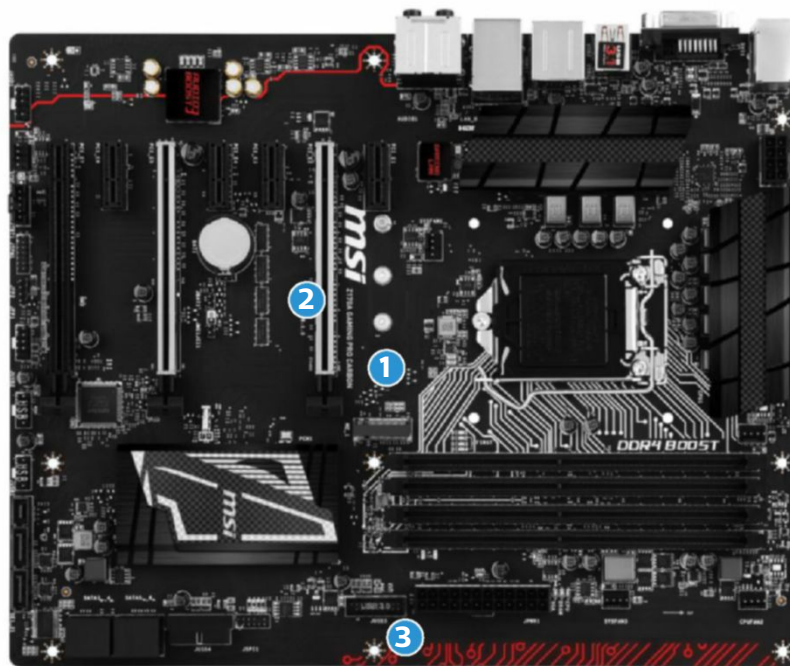
You can select a specific colour using an RGB palette

- 1** The 4x PCI-E3 M.2 slot is sensibly positioned above the primary 16x slot
- 2** The two chrome-plated slots offer eight lanes each in dual-GPU setups
- 3** The RGB LEDs light up printed patterns next to the 24-pin power connector

priced Z170 Pro Gaming motherboard in all the tests. The MSI was a tad slower than some other boards in our Total War: Attila benchmark, but again beat the Asus Z170 Pro Gaming.

Audio performance was much better than some other MSI Z170 boards we've seen too, with a dynamic range of 103.8 dB(A) and noise level of -103.9 dB(A) matching the vast majority of other Z170 boards we've tested. By comparison, the MSI Z170A SLI Plus only managed 96.3dB(A) and -96.4dB(A) respectively. Slotting a Samsung 950 Pro M.2 SSD into the M.2 slot also saw the MSI match the results from other boards we've tested with the SSD, netting read and write speeds of 2,300MB/sec and 957MB/sec. The SATA 6Gbps results of 563MB/sec and 531MB/sec are on the money too.

Meanwhile, overclocking was easy, although we needed a hefty 1.42V to get our CPU to a maximum of 4.8GHz – comparatively, we achieved the same clock speed with just 1.34V on the Asus Z170 Pro Gaming. This overclock saw the power consumption under load hit 189W, but that isn't excessive compared with much of the competition. This overclock saw the system score rise to 147,311 – a great result, even if it's a little behind the Asus Z170 Pro Gaming's overclocked result. The overclocked Total War: Attila results match those of pricier boards we've tested too.



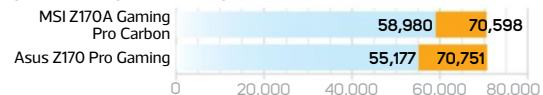
Conclusion

Apart from a couple of small niggles with the layout, the MSI Z170A Gaming Pro Carbon makes a great impression, and the RGB lighting is the icing on the cake, even if it's a little basic. The software suite in particular is very handy, and the £120 price tag makes it a solid deal. If you're not interested in the RGB lighting, though, ASRock's Z170 Extreme4 offers a more expansive feature set for less money.

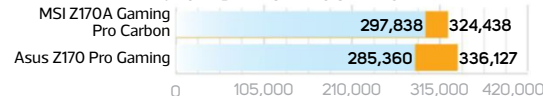
ANTONY LEATHER

CUSTOM PC REALBENCH 2015

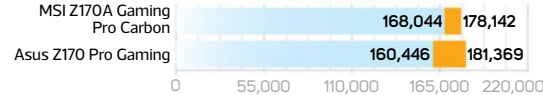
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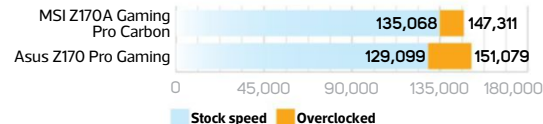
HANDBRAKE H.264 VIDEO ENCODING



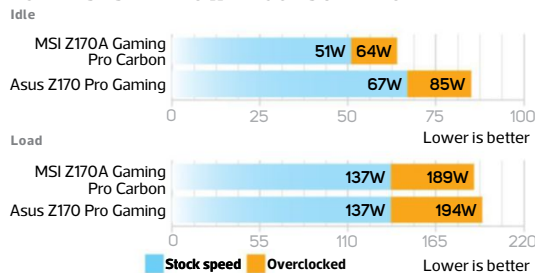
HEAVY MULTI-TASKING



SYSTEM SCORE



TOTAL SYSTEM POWER CONSUMPTION



TOTAL WAR: ATTILA



PERFORMANCE
35/40
VALUE
25/30

FEATURES
24/30

OVERALL SCORE
84%

VERDICT

If you want RGB lighting on a budget, the Z170A Gaming Pro Carbon is a great board, though you can get better value for money and features elsewhere.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

ATX MOTHERBOARD

Gigabyte Z170-Gaming K3 / £97 inc VAT

SUPPLIER www.scan.co.uk

If you're on a tight budget, opting for a Skylake Z170 system is thankfully becoming more affordable all the time. There are now plenty of motherboards below the £100 mark, such as this Z170-Gaming K3 from Gigabyte, which can push most CPUs to their air-cooled limits, so any extra cash will only net you some more features and sometimes a little extra performance.

However, there are only a few notable features omitted from the Z170-Gaming K3. You get two USB 3.1 Type-A ports, although there's no reversible Type-C port. There's also an M.2 port, which supports 4x PCI-E 3 NVMe SSDs such as Samsung's 950 Pro, plus there are two SATA Express ports, sharing the full complement of six SATA 6Gbps ports controlled by the Intel chipset. The board also sports isolated audio circuitry and Chemicon capacitors, with a claimed 115dB signal-to-noise ratio and 104dB recording quality. The top 16x PCI-E slot is reinforced with a steel shield too.

That's a solid set of specifications for a board costing under £100, although there are some omissions too. While two-way CrossFire is supported, there's no support for SLI and the second 16x PCI-E slot can only run in 4x mode, which isn't ideal if you're using two high-end GPUs.

There are also no on-board overclocking features – it lacks on-board power and reset buttons, a clear-CMOS switch and there's no LED-POST code display either. Comparatively, the ASRock Extreme4 (see Issue 147, p41) still has all these features, yet only costs £111 inc VAT from www.scan.co.uk at the moment.

Thankfully, other aspects of the Z170-Gaming K3 are up to scratch. The layout is generally good and the M.2 port and top 1x PCI-E slots are well placed separately above the top 16x slot, so should always be accessible whatever other expansion cards you use. That said, the M.2 port is so close to the CPU socket that large CPU coolers may well obstruct access to it.

The two 16x slots are also double-spaced so if you decide to opt for a two-way GPU setup, proximity of the cards and airflow room shouldn't be issues.

Aesthetically, the Z170-Gaming K3 is very appealing too. It sports snazzy red details and a dark brown – not black – PCB, which doesn't come across clearly in photos. Gigabyte has also gone to town with some lighting too. It isn't fully customisable RGB lighting, but there are some powerful red LEDs illuminating the audio circuitry, and what we can only describe as go-faster stripes on the opposite side of the PCB. These lights

can also be tied into effects that are configurable in the EFI, such as pulsing or beating in response to music playback.

Performance

Stock-speed results from the Z170-Gaming K3 were a little low, with a total system score of 126,333 in our RealBench 2015 test suite, compared to 135,694 from the ASRock Z170 Extreme4. There wasn't a big performance deficit in our Total War game test, though, and power consumption was very frugal too. We couldn't find a reason for the latter – setting the XMP profile had all of our test kit's components working correctly – it looks as though Gigabyte has really nailed power efficiency.

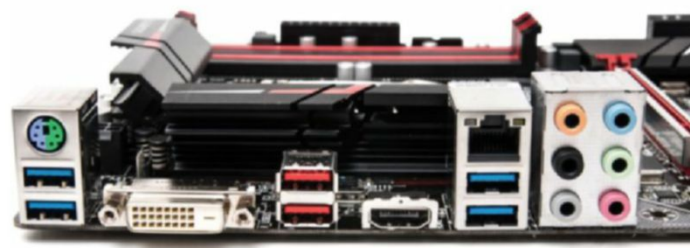
The Gigabyte excelled in our audio tests though. Noise and dynamic range results of -103.9dBA and 103.8dBA respectively are excellent for such a cheap motherboard, being much better than those of the MSI Z170A SLI Plus, which languished in the mid-nineties for both results. Even the best boards we've tested only manage one or two dBA higher, so there's little need to get a separate sound card with this board unless you need additional features or are gunning for maximum audio quality.

The Z170-Gaming K3 was on the ball in the storage tests too, matching the read and write speeds we've seen so far on other boards in our SATA 6Gbps CrystalDiskMark test, with results of 561MB/sec and 524MB/sec respectively. Meanwhile, our 256GB Samsung 950 Pro hit 2,293MB/sec and 959MB/sec read and write speeds from the M.2 port.

Overclocking the Z170-Gaming K3 was simple, although the EFI is a little clunky and outdated. Our overclock to



/SPECIFICATIONS

Chipset Intel Z170**CPU socket** Intel LGA1151**Memory support** 4 slots: max 64GB DDR3 (up to 3600MHz)**Expansion slots** Two 16x PCI-E 3, four 1x PCI-E 3**Sound** Realtek ALC1150**Networking** Killer E2201 Gigabit LAN**Overclocking** Base clock 98–341MHz, CPU multiplier 8–80x; max voltages, CPU 1.8V, RAM 2V**Ports** 6x SATA 6Gbps (Z170), 1x M.2, 2x USB 3.1 Type-A, 4x USB 3, 1x LAN, 8-channel surround audio out, line in, mic, 1x HDMI 1.4, 1x DVI-D, 1x PS2**Dimensions (mm)** 305 x 244

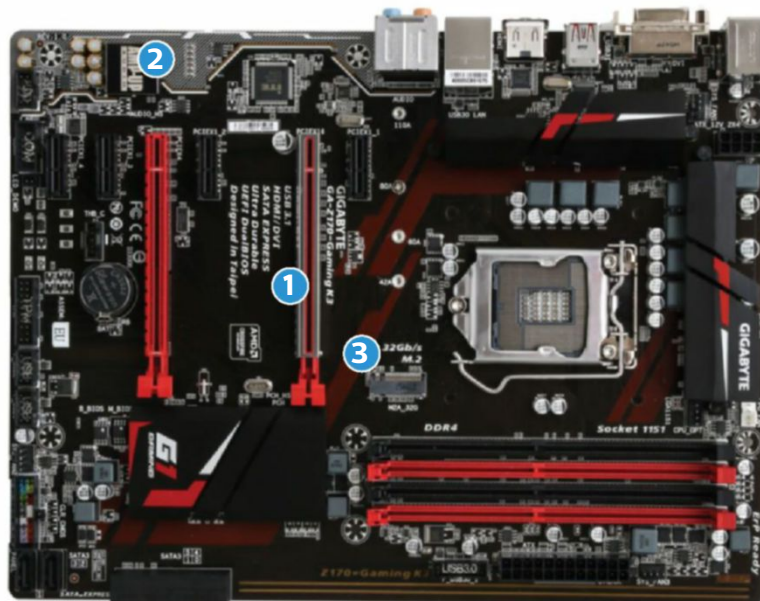
- 1** The top 16x PCI-E graphics slot is reinforced with a steel shield
- 2** The isolated audio circuitry produced great results in our tests
- 3** The M.2 slot is sensibly positioned above the top 16x PCI-E slot

4.8GHz just required a vcore of 1.4V and the multiplier to be set to 48x, so it's clear the board won't shy away from some decent returns in this respect if you have a decent cooler – we used a Corsair H80i GT for our tests. Thankfully, this overclock also restored some balance to the benchmarks. The overall score rose to 147,100 – enough to match the MSI Gaming Pro Carbon (see p26), and the Gigabyte bettered the ASRock Z170 Extreme4 in the video encoding test too. This overclock did result in the load power consumption rising to 197W, though, which is one of the highest results we've seen, albeit only by 10–15W.

Conclusion

The Z170-Gaming K3's stock speed results are a little disappointing, but once it's overclocked, it's on a par with even much more expensive boards. It's easy to overclock too, managing to hit 4.8GHz, which is the highest frequency we've seen from the majority of Z170 boards we've tested.

Audio performance is excellent too, and it kept up with the best motherboards in terms of storage results. Combined with a good layout, all you're missing are some overclocking tools and SLI support, but those key omissions are the

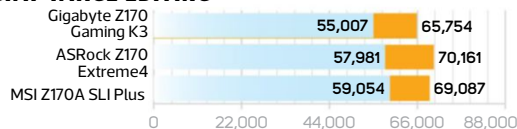


Gigabyte's main problem. For just £14 more, ASRock's Z170 Extreme4 is just as good at overclocking, has similar audio and storage performance, but also has the full complement of overclocking tools, a USB 3.1 Type-C port, a superior EFI and SLI support. Unless you're on a very tight budget, that extra cash is ultimately worth paying.

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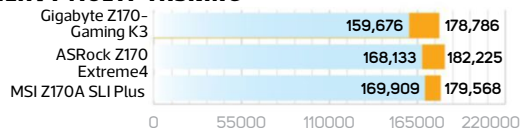
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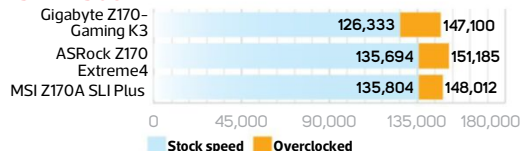
HANDBRAKE H.264 VIDEO ENCODING



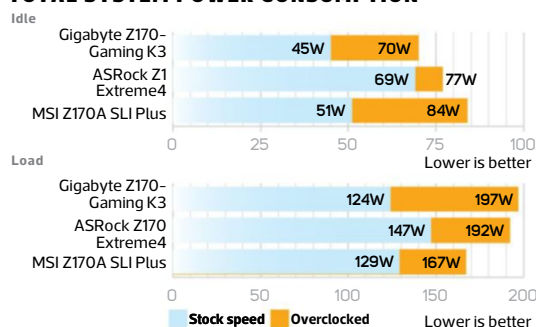
HEAVY MULTI-TASKING



SYSTEM SCORE

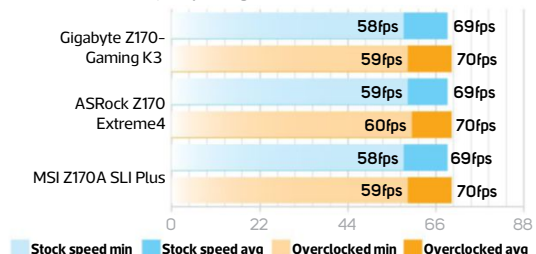


TOTAL SYSTEM POWER CONSUMPTION



TOTAL WAR: ATTILA

1,920 x 1,080, 0xAA, Quality setting



PERFORMANCE

25/30

FEATURES

24/35

VALUE
32/35

OVERALL SCORE

81%

VERDICT

A decent budget motherboard for the money, although the competition outdoes it in a number of areas for just a little extra cash.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

GAMING LAPTOP

CyberPower Fangbook 4 SK-X17 / £1,909 inc VAT

SUPPLIER www.cyberpowersystem.co.uk

CyperPower's Fangbook 4 SK-X17 brings the joys of active sync tech to the mobile world, featuring Nvidia's G-Sync tech in order to eliminate stuttering and tearing artefacts in games. It's a monster of a machine too, with a 17.3in screen and a huge chassis, although its matt black exterior is aesthetically inconspicuous. The lid is only decorated by a subtle, metal-effect CyberPower logo, and the keyboard is simply surrounded by a row of discreet buttons. There's a classy touch from the keyboard backlight, though, as well as some subtle lighting beneath the front edge.

Build quality is sturdy too.

It's only possible to push down the wrist rest with a fair amount of force, and there's only a little movement between the lid and the screen. The base is also rock-solid, and you can tug off the base panel to reveal accessible components and cooling gear. The storage, memory and Wi-Fi

chip can all be reached, and there's a spare M.2 socket.

Move to the edges and you'll find six USB 3 ports, four audio jacks, a card reader and a USB 3.1 Type-C connection. Meanwhile, the display output selection includes HDMI and mini-DisplayPort, and there's Killer Gigabit Ethernet and Intel dual-band 802.11ac Wi-Fi too. It's a versatile machine.

The impressive build quality and versatility comes with one main caveat: the Fangbook is 47mm thick and weighs 3.9kg. The huge size means the keyboard has a strong base,

which helps for hammering keys. The keys are the usual Scrabble-tile affair, with good travel and a consistent, quiet action. They're a little soft compared with mechanical keys, but you can't expect a laptop to replicate the whole desktop experience. The touchpad has a couple of minor issues though. The buttons are a little too stiff, the surface has too much friction and it doesn't support gestures. It's adequate, but you'll want a USB mouse if you're gaming at a table.

Gaming power comes from a desktop Nvidia GeForce GTX 980, with 8GB of GDDR5 memory. The chip has 2,048 stream processors and a 1266MHz maximum boost speed. Meanwhile, processing power comes courtesy of a Skylake Core i7-6820HK. It's a mobile chip, but its 2.7GHz clock speed is a little higher than that of the more common i7-6700HQ, and it will reach 3.6GHz with Turbo Boost. It has an unlocked multiplier as well, although CyberPower hasn't applied an overclock. Elsewhere, the specs are business as usual. There's 16GB of 2133MHz memory, a fast 256GB Samsung SM951NVMe



M.2 SSD and a 2TB hard disk.

Then there's the 17.3in screen, which has a 1,920 x 1,080 resolution and a matt finish, both of which are sensible design decisions. The former means that games will look sharp at the native resolution, at maximum settings, without unduly taxing the graphics core (in fact, the desktop GTX 980 is overkill for this resolution), and the latter means bright lights won't interfere with gameplay.

The panel also supports Nvidia G-Sync, making the Fangbook the first laptop we've reviewed with this technology, and it's a welcome addition. It's designed to synchronise the GPU's frame rate with the panel's refresh rate, which means that tearing effects are eliminated. It works extremely well; we tested it with Nvidia's Pendulum demo, and the smoothness of G-Sync makes non-synced gaming look decidedly choppy.

Finally, the Fangbook includes a one-year warranty covering both parts and labour, which includes a month of collect and return service. It's a middling deal, and we'd ideally like to see two years of parts coverage with such a machine, although paying £19 more extends the collect and return coverage to a full year.

Performance

The desktop-class GTX 980 sliced through our games benchmarks. With Fallout 4 running at Ultra settings with anti-aliasing, the Fangbook hit a smooth minimum of 55fps, and it stayed above 60fps in The Witcher 3 at High graphics settings, and even enabling HairWorks resulted in a solid minimum of 46fps. Even Crysis 3 couldn't stop the Fangbook, which never dropped below 48fps in this demanding game.

The high-end quad-core mobile CPU romped through our application tests as well. Its video encoding score of 227,562 is the kind of result we expect from desktops, showing that this machine has enough power to handle

/SPECIFICATIONS

CPU 2.7GHz Intel Core i7-6820HK

Memory 16GB 2133MHz DDR4

Graphics Nvidia GeForce GTX 980 8GB

Screen 17.3in 1,920 x 1,080 Nvidia G-Sync IPS

Storage 256GB Samsung SM951NVMe M.2 SSD, 2TB hard disk

Weight 3.9kg

Networking Gigabit Ethernet, dual-band 802.11ac Wi-Fi

Ports 6 x USB 3, 1 x USB 3.1 Type-C, Gigabit Ethernet, 4 x audio, SD card slot, HDMI, mini-DisplayPort

Dimensions (mm) 428 x 295 x 47 (W x D x H)

Operating system Windows 10 Pro 64-bit

Warranty One year parts and labour, including one month of collect and return cover

both multi-threaded software and high-end games. Meanwhile, the Samsung PCI-E NVMe SM951SSD delivered sequential read and write results of 1,850MB/sec and 1,421MB/sec, which are great speeds.

What's more, the Fangbook performed well without ever proving too hot or loud. The respective CPU and GPU delta Ts of 66°C and 61°C are high but not toasty enough to cause concern. The laptop was quiet when idle and its noise was modest when running games – its fans spun up after ten minutes, but then slowed down when the components were cooled. It modulated between these two levels during gameplay, and neither sound was too intrusive.

Then there's the 1080p panel, which has a good brightness level of 324cd/m², and its black level of 0.29cd/m² and contrast ratio of 1,117:1 are decent results too, meaning that dark areas in games will look deep and well defined, while colours across the board will be punchy. The panel is consistent too, only losing around 6 per cent of its brightness from the top edge, and less from other areas of the screen, with similar deviations in colour temperature. Colour accuracy isn't brilliant though. The colour temperature of 7,784K is overly cool, the delta E of 3.18 is middling and the sRGB gamut display level of 86.1 per cent is average. As a result, colours in games will look a little cool, but it's not a deal breaker.

Even the sound is reasonable. The speakers are managed by the Sound Blaster Cinema app. By default, it uses Music mode, where the subwoofer's reasonable thump doesn't overpower other sounds and, while the meaty mid-range is a little muffled, high frequencies are clear and detailed.

Finally, there's the battery, which is never a strong point for gaming laptops. With the screen brightness ramped up and a game benchmark running, the CyberPower lasted for



56 minutes – on a par with its rivals. The bottom line is simple: keep the Fangbook plugged into the mains.

Conclusion

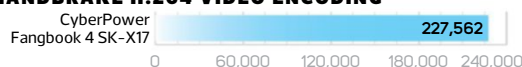
CyberPower's Fangbook 4 SK-X17 might be costly, thick and heavy, but it makes up for its size with ample versatility, smart design and loads of power. The GTX 980 scythes through games, the CPU is fast and there's a rapid SSD and a G-Sync screen. If you have the money, it's one of the best no-nonsense gaming laptops we've seen.

MIKE JENNINGS

CPC REALBENCH 2015 GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING



LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 89.45%

SPEED
24/25

DESIGN
22/25

HARDWARE
23/25

VALUE
21/25

OVERALL SCORE
90%

FALLOUT 4

1,920 x 1,080, Ultra Detail, TAA



WITCHER 3

1,920 x 1,080, High Detail, AA on, HairWorks off



CRYSIS 3

1,920 x 1,080, Very High Detail, 0x AA



VERDICT

Heavy, bulky and subtly styled, but this laptop has it where it counts, thanks to great performance, versatility and features.

Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

BOARD GAME

Risk Legacy / £40 inc VAT

If, like ourselves, you were taught to look after your toys as a child, then Risk Legacy may pose a challenge. The whole concept is that the game is both disposable and changeable. Parts of the game get ripped up and thrown in the bin, you scribble on the board and stickers get stuck on the cards, all of which then has an impact on later games.

It's initially a bit nerve-wracking, but once you're in the swing of it, you start actively competing to stamp your own marks on the game, lest your fellow players beat you to it. It makes for great fun for the 15 or so games that it lasts, and at the end of it, you'll have a board that's completely unique to you and your gaming group, which almost makes up for the fact that you won't own a playable set of Risk Legacy anymore.



SUPPLIER www.365games.co.uk



MOUSE MAT

Roccat Kanga / £18 inc VAT

Unusually for a gaming peripheral, the packaging of the Kanga is refreshingly free of hyperbolic marketing speak. It's a simple rubber-backed fabric mat, and it covers the basics well. The black fabric upper is very tightly woven, which makes it an ideal tracking surface for the majority of today's gaming mice – all three of our test mice tracked perfectly on it. The fabric's slight grain does provide a noticeable touch of friction, however, to which you'll need to become accustomed if you're used to the glide of a less textured mat.

The only downside is that the Kanga's edges aren't rounded or bonded, a feature commonly seen on more premium mats. As such, the fabric upper and rubber backing may peel apart over time, but you can't expect everything for a price of just £8, and the Kanga is otherwise a solid, basic mouse mat for a generous price.



SUPPLIER www.amazon.co.uk

TABLET STAND

Octa Tablet Tail / £38 inc VAT

While giving your tablet a tail may sound daft, it's a great idea in practice. The first part of the Tablet Tail is the Dock Cap, which sticks to the back of a tablet via a suction cup. The amount of pressure you need to exert to get a good seal is slightly disconcerting, but it stays stuck fast once it's on your tablet.

The tail then locks securely into the cup, and it can then be posed in various directions or even twisted around objects, while holding your tablet in place.

Amazingly, the tail was substantial enough to hold a tablet in whichever orientation we left it, without drooping over time – we found a surprising number of uses for it. The only slight issue is that, while the suction mechanism will happily stick to a tablet, it doesn't stick to all tablet cases.



SUPPLIER

www.amazon.co.uk





BLUETOOTH SPEAKER

UE Boom 2 / **£130** inc VAT



With a similar size and weight to a large can of beer, the Boom 2 is a capable speaker. Audio is tight and controlled, with punchy bass notes underneath a warm mid-range. It's a mix that makes for a satisfying experience, especially with country or light rock music. The physical package is impressive too. Its waterproof mesh exterior is IPX7-rated, meaning it can be fully submerged for up to half an hour. Battery life is very good too – we measured just over 11 hours of continuous play.

There's also a dedicated app, which isn't vital for use, but cleverly enables up to three devices to connect to the Boom 2 so you can set up collaborative playlists. Naturally, you pay for this quality, but if you'll get a lot of use out of a ruggedised speaker, the UE Boom 2 is one of the best we've seen.



SUPPLIER www.johnlewis.com

TRAVEL ROUTER

StarTech Wireless Travel Router / **£26** inc VAT

The idea behind StarTech's Wireless Travel Router is simple – this dinky little box takes a wired Ethernet connection and regurgitates it as a Wi-Fi network that you can configure with all the normal security settings. Cleverly, the unit is designed to be powered by an iPad charger, fitting snugly over the top of it and plugging into its USB port.

It's designed to be used by **business travellers stuck in dull hotel rooms**, although its days are likely to be numbered by the increasing proliferation of free Wi-Fi in even cheap hotels. It can be used as a Wi-Fi range booster too, which at least gives it another job. It's a well-designed and reasonably priced device that works well if you know you'll need it, but its appeal is otherwise limited.



SUPPLIER www.dabs.com



USB DRIVE

HyperX Savage USB 64GB / **£30** inc VAT

With the rise of the cloud and the increasing ubiquity of quick fibre broadband, you could argue that USB drives have had their day. We suspect however that, like us, many people still find the speed, reliability and physical solidarity of USB drives such as HyperX's USB3 Savage drive very useful, especially when moving very large files. Happily, the blistering speed of the drive makes shifting bags of data a doddle – we measured read and write speeds of 271MB/sec and 122MB/sec respectively when transferring a mixed batch of large and small files, making the Savage one of the fastest USB drives we've seen to date. It looks smart too, and while it's overkill (and pricey) if you're just looking for an everyday drive, it's a worthwhile investment if you often find yourself schlepping around large files.



SUPPLIER www.hyperxgaming.com

Seen something worthy of appearing in Custom Kit? Send your suggestions to paul_goodhead@dennis.co.uk

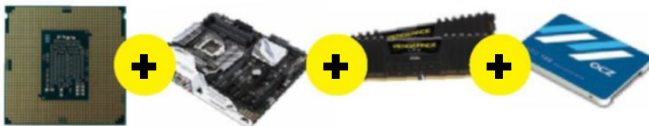
How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

PROCESSORS

We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1151



Intel LGA1151 CPU + Asus Z170 Deluxe (ASRock Z170 Extreme4 for Core i3 6100 test) + 16GB Corsair Vengeance LPX 2666MHz DDR4 + 240GB OCZ Arc 100

INTEL LGA2011-V3



Intel LGA2011-v3 CPU + Asus Rampage V Extreme + 16GB Corsair Vengeance LPX 2133MHz DDR4 + 512GB Crucial MX100

AMD FM2+



AMD FM2+ APU + MSI A88X-G45Gaming + 16GB Corsair Vengeance Pro 2133MHz DDR3 (GPU testing) + 8GB Corsair Vengeance Pro 1600MHz DDR3 (CPU testing) + 240GB Crucial M500

COMMON COMPONENTS



AMD Radeon R9 390X* + Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

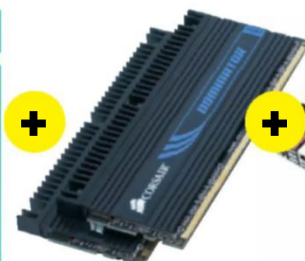
*Please note: We test AMD FM2+ APUs using the on-board graphics, not the AMD Radeon R9 390X

GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.



4.2GHz Intel Core i5-3570K



8GB Corsair Dominator 2400MHz DDR3



Asus Maximus V Extreme



Windows 10 64-bit



The graphics card we're reviewing

= SCORES

CUSTOM PC REALBENCH 2015

INTEL REFERENCE



AMD REFERENCE

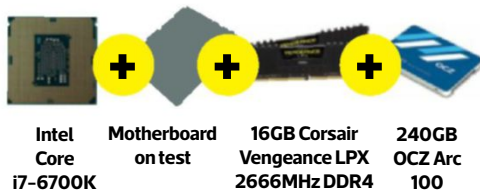


Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

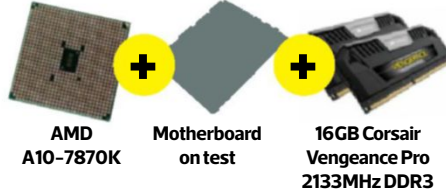
MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1151



AMD FM2+



INTEL LGA2011-V3



COMMON COMPONENTS



TESTS: We use Custom PC RealBench 2015 and Total War: Attila, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum QPI, base clock or HTT as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

*Please note: We test AMD FM2+ motherboards using the on-board graphics, not the AMD Radeon R9 390X

The Awards



EXTREME ULTRA

Some products are gloriously over the top. These items of excellent overclock earn our Extreme Ultra award.



PREMIUM GRADE

Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.



PROFESSIONAL

Products worthy of the Professional award make you and your business appear even more awesome.



APPROVED

Approved products are those that do a great job for the money; they're the canny purchase for a great PC.



CUSTOM KIT

For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.



TESTS: By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test GTA V, Shadow of Mordor, Crysis 3, Fallout 4 and The Witcher III: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

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LABS TEST

Mechanical magic

Mechanical keyboards are everywhere, giving you loads of choice between switches and features. Our roundup of 15 keyboards will point you in the right direction

Mechanical keyboards have flourished over the past couple of years, attracting hordes of enthusiasts and gamers with their solid clicks and precise action. So it's no surprise that so many companies want to get a slice of the action. There's now more choice than ever before, and we're also seeing many features introduced with this new wave of keyboards, such as RGB lighting and ridiculous levels of key customisation. There's also a wider variety of switches coming to the forefront, as both companies and customers seek alternatives to Cherry.

In theory, as a mechanical keyboard is a long-term investment, having so much choice available means you're more likely to find one

that's perfect for you. However, with so many companies, styles, switches and features vying for your attention, the waters are undeniably muddled.

Luckily for you, we're here to sift through the dirt. We've rounded up 15 of the latest mechanical keyboards, including some brand-new ones, with prices ranging from £81 to £155 inc VAT.

We'll be putting each one through its paces to establish where it delivers and where it falls short, as well as explaining all its capabilities, enabling you to make a well-informed choice about your impending keyboard upgrade.

MATTHEW LAMBERT

Featured this issue

Asus Strix Tactic Pro / p40

Cougar Attack X3 / p40

Corsair K70 RGB / p41

Corsair Strafe RGB MX Silent / p42

Cooler Master MasterKeys Pro S / p44

Cooler Master Quick Fire XTi / p45

Ducky Shine 5 / p46

Logitech G810 Orion Spectrum / p48

Roccat Ryos MK FX / p50

Razer BlackWidow Chroma Stealth / p52

Razer BlackWidow Ultimate 2016 / p54

QPAD MK-90 / p54

Tt eSports Poseidon Z RGB / p55

SteelSeries Apex M800 / p56

Xtrfy XG1-R LED / p57

How we test

While it's relatively easy to establish a processor's speed and a graphics card's frame rate, one person's dream keyboard could well be another person's nightmare. There's simply too much variance in preference of mechanical switch type, features and aesthetics for there to ever be one keyboard to rule them all.

As such, while our reviews are based solely on our use of the products, we don't award or deduct points when a keyboard has been geared towards a specific type of user, such as making use of one type of

switch versus another one. Instead, we focus on using each product as much as possible across different applications, especially word processing and gaming, to give us the best idea of its capabilities and limitations, and we aim to make the results clear in our reviews.

Each keyboard is graded in three areas. The Features score is worth 35 per cent of the overall score, which is essentially a tally of the features present, weighted towards more useful ones (a wrist rest is worth more than a replacement set of WASD keys, for example). The Design score has

the largest weighting at 40 per cent, and it includes build quality and ease of use. This weighting prevents keyboards with the most features winning by default, as the priorities with a mechanical keyboard are that it's built to last and any features are easily usable. For this reason, we give any software (where applicable) a full workout – buggy or confusing software will lose points, as it will make your everyday experience worse. Lastly, the Value score is worth 25 per cent of the score, and is calculated by dividing the other two scores by the retail price.

Mechanical switches

Cherry MX

Cherry's German-built MX switches are the most popular ones on the market. They have a sterling reputation, but they're pricey. Cherry MX Reds are light, with a 45cN actuation force, and linear, meaning there's no discernible feedback at the actuation/reset point. The Brown varieties are just as light but have tactile feedback, with a detectable bump as they're actuated. Blue switches are a little heavier at 50cN, and have both tactile and audible feedback, making a distinctive click sound on every press. Blacks are just like Reds but heavier at 60cN – they're not seen in this roundup but are available on some models.

All Cherry MX switches have an iconic cross-shaped plunger and 4mm of total travel, although actuation and reset points vary. The standard variety has room for a small LED at the top of the housing, but Cherry now produces RGB variants with clear housing and a larger, surface-mounted RGB LED inside.

Lastly, Cherry's new MX Silent switches are exclusive to Corsair for six months, and use a series of patented technologies to reduce noise. The unique stem is made from a plastic polymer and thermoplastic elastomer, and the switch includes both top and bottom impact absorbers.

Kailh

Kailh essentially produces Cherry MX clones, as the relevant patent has expired.



Cherry now produces RGB MX switches with clear housing and a large, surface-mounted RGB LED inside, as seen here on the Ducky Shine 5

Some companies, such as Tt eSports and Razer, also brand Kailh-produced switches branded as their own. There can be slight differences in specs between the switches and the Cherry MX ones, but the overall design, including the cross-shaped plunger, is the same.

Logitech Romer-G

Logitech's Romer-G switches were developed with Omron. Like Cherry MX Browns, they have a 45cN actuation force and tactile feedback, but a shorter (1.5mm) actuation point. They also have a different design, with a square-shaped plunger and

a surface-mounted RGB LED in the middle with a lens to focus the light upwards. They also use two contact points instead of one, so it still works if one point of contact fails.

SteelSeries QS1

SteelSeries' QS1 switches are made by Kailh, but they aren't Cherry MX derivatives and SteelSeries has its own testing facilities. With a square plunger and central LED, they're similar to Romer-G switches but not identical. They have a 45cN actuation force, a 1.5mm actuation point and two contact points, but they're linear, rather than tactile.

Asus Strix Tactic Pro / £81 inc VAT

SUPPLIER www.scan.co.uk

The Asus Strix Tactic Pro is the least expensive keyboard on test, and it shows in a few places. It's generally solid but less so than most of the others on test, and its grip is a little compromised when the rear legs are extended. Also, the plastic body, thumb-activated macro keys and dedicated media keys all feel a little cheap.

That said, you get plenty for your money – a fully mechanical key set with n-key rollover, backlighting, 13 dedicated macro keys and eight additional macro keys via F1-F8.

There are three on-board profiles too, and you can have even more by tying additional profiles to programs or games using the simple software.

Macros can be recorded on the fly, and all the usual delay-recording and macro-playback options are available. Keys can also launch specific programs or be mapped to keyboard or mouse commands. However, none of the standard keys can be reprogrammed, and the numerous macro keys result in a wide keyboard. Also, the three

thumb-activated buttons require too much of a stretch to reach.

A key puller and four blank orange keycaps are supplied, but no wrist rest. Still, the Cherry MX switches make the typing excellent. The keycaps are perhaps overly smooth, but that's nitpicking. Our sample has Blue switches, which have useful feedback for typing, but can be distracting in games – luckily, you can choose between four types.

Meanwhile, the FN key unlocks various functions, including NKRO toggle (disabling it can increase compatibility with older BIOSes),

Windows key locking, profile switching and Macro mode for the F1-F8 keys. All these features, as well as the usual lock buttons, have a series of indicators along the top edge. In theory, these indicators are good for letting you know the state of your keyboard at a glance, but disappointingly, the printed text telling you what each light represents is tricky to read at normal angles.

The orange backlighting also has on-board controls to switch between three illumination levels and a breathing mode. Sadly, though, quality is lacking – the LEDs are quite dim and



Cougar Attack X3 / £85 inc VAT

SUPPLIER www.overclockers.co.uk

With an aluminium faceplate and raised keys, the Attack X3 has more than a little Corsair influence in its design. Sadly, while it's strong, it lacks the finesse of Corsair's offerings thanks to the flimsy plastic top and bottom sections, as well as its bulky design.

The reinforced cable and solid grip are welcome, but the red backlight is quite garish, bleeding badly through dual-character keys and reflecting harshly off the metal.

There's no wrist rest or key puller either, but you can't expect everything for £85 inc VAT, and you do get a full set of Cherry MX Brown keys, which are as lovely as ever to use, and n-key rollover is supported too, as well as 6KRO for compatibility.

Meanwhile, the FN key, which is annoyingly located where the left Windows key usually sits, can activate a Windows key lock and switch between the three on-board profiles, although there are no indicators to show which profile is enabled. The FN key also

unlocks media controls but, while it's good to see dedicated volume keys in the feature set, the Attack X3's plastic media keys look and feel a little cheap.

On the plus side, the software permits customisation of almost every key for each profile. There's a good variety of jobs you can assign to keys, including shortcuts to programs, although there's a ten-macro limit per profile. The macro editor itself is surprisingly powerful too, featuring mouse click and movement recording, as well as import/export duties.

However, the software's drag and drop interface is sluggish, requiring you to drag current settings to a small bin rather than just overwriting them, for example. Also, while a key map shows you which keys have custom functions, it doesn't show the function to which they've been mapped, instead just showing a generic shortcut icon. It can also be slow when programming settings, and the interface as a whole isn't very user-friendly.

The Cougar Attack X3's price tag is certainly appealing, especially as you get a full set of genuine Cherry MX keys and a fair



only illuminate the centre of the keycaps, so larger, dual-symbol keycaps aren't fully lit.

The Strix Tactic Pro is the best sub-£100 keyboard on test, and it offers great value for money, but a few niggly issues with design and build quality keep it out of award territory.

DESIGN 30/40 **FEATURES** 26/35 **VALUE** 24/25

VERDICT

The best value keyboard on test, but it's held back by a few issues with build quality and design.

OVERALL SCORE
80%

/SPECIFICATIONS

Connection Wired, USB

Cable 1.8m, braided

Material Plastic

Switch type Cherry MX Blue (Black, Brown and Red available)

Backlighting Orange

Ports No

Wrist rest No

Extras 21 macro keys (13 dedicated), n-key rollover, dedicated media keys, Windows key lock, key removal tool, 4 replacement keycaps

degree of customisation too. It definitely has the potential to be a strong value offering, but it's let down by the quality of its lighting and software, as well as a few irksome design mistakes.

DESIGN 31/40 **FEATURES** 23/35 **VALUE** 22/25

VERDICT

Loads of features for an attractively low price, but they could be implemented better.

OVERALL SCORE
76%

/SPECIFICATIONS

Connection Wired, USB

Cable 1.8m, braided

Material Plastic, aluminium

Switch type Cherry MX Brown (Black, Blue and Red available)

Backlighting Red

Ports No

Wrist rest No

Extras Programmable keys, media keys, dedicated volume keys, Windows key lock



Corsair K70 RGB / **£155** inc VAT

SUPPLIER www.amazon.co.uk

The Corsair K70 RGB's brushed aluminium unibody faceplate adds allure, class and strength like no other keyboard's faceplate. The cable is non-detachable but secure and thick, and the keyboard's power draw requires two USB ports, despite having no pass-through feature. Grip is excellent, and even the non-mechanical buttons – a dedicated brightness control, a Windows key lock and a set of dedicated media keys – are well made with solid action.

The K70 uses Cherry MX RGB switches, and our sample had the Red variety, which offered its usual high standard of quality and consistency; it's also available with Brown switches. Meanwhile, comfort is aided by the removable soft-touch wrist rest. It's more of a palm rest in terms of size, but it keeps the keyboard's profile small while still adding welcome support. Its material is also more comfortable than that of the Strafe's rest (see p42).

The K70 RGB is relatively loud in use, though, even with the linear Red switches. The key caps are raised, and the switch is embedded in the aluminium plate – an arrangement that emphasises the noise of bottoming out and the key's return.

In terms of features, the K70 RGB supports n-key rollover, although a switch on the back can disable it for older BIOS compatibility. There are no macro buttons, but that isn't a big deal when, as with the Strafe, you can reprogram virtually any key to almost any function you can imagine. The K70 RGB doesn't have a second layer of commands, as with Roccat's EasyShift+ system, but otherwise, it has the deepest level of customisation on test, and the macro editor is the most advanced one we've seen.

Similarly, the per-key RGB lighting is capable of all sorts of effects. It covers the spectrum well, with no awkward colour transitions, and whites aren't too bad either. There's a little bleeding into the lower half of dual-symbol keys, so it isn't perfect, but the RGB switches' transparent housing helps to prevent the light from being concentrated in just the centre of the keys. The latest CUE software is much easier to use than previous versions, although there's still a learning curve.

Also, only basic lighting effects can be saved to the keyboard; complex ones and custom commands require the software, which is a shame.

The price tag is, of course, the K70 RGB's other downside, but it exudes quality at every turn – if you can afford the investment, you'll be rewarded with an excellent desktop companion.

DESIGN 37/40 **FEATURES** 30/35 **VALUE** 15/25

VERDICT

Very costly, but fine craftsmanship that you can tune to your heart's content.

OVERALL SCORE
82%

/SPECIFICATIONS

Connection Wired, 2 x USB

Cable 2m, braided

Material Plastic, aluminium

Switch type Cherry MX RGB Red (Brown available)

Backlighting RGB, per-key

Ports No

Wrist rest Yes, removable



Corsair Strafe RGB MX Silent / £145 inc VAT

SUPPLIER www.box.co.uk

The Strafe doesn't have the same aesthetic draw as the aluminium-clad K70 RGB, and the top edge is a little excessive in size, but it's fairly smart-looking with its sharp angles. It's generally solid and the textured plastic finish resists fingerprints well. The rear feet, however, feel flimsy and they significantly lower the board's grip on the left when extended. You'd have to play aggressively for the keyboard to move, but other keyboards have better grip.

Uniquely, the Strafe uses Cherry MX Silent RGB switches, for which Corsair has a timed exclusivity deal. They're designed to have the same light, linear action as Red switches while being significantly quieter. The action is just as satisfying as a standard Red switch, and consistency across keys is high too. Noise is clearly reduced too, regardless of whether you type lightly or heavy-handedly.

When typing or playing high-APM (actions per minute) games where you tend to bounce off keys quickly, the rebound noise is still pronounced and bigger keys such as the spacebar are still loud. However, the difference is night and day compared with the K70 RGB. The Logitech and SteelSeries keyboards on test give it a run for its money, but the Strafe RGB MX Silent is definitely the quietest Cherry MX experience available by a fair margin.

The small wrist rest is a welcome touch too, especially as it's detachable, but the material is firmer and more textured than ideal for comfort. Also included is a key puller, as well as replacement sets of MOBA and FPS

keycaps, which are coloured, textured and contoured. As with the K70 RGB, you'll find dedicated Windows key lock and brightness control buttons with a satisfactory action, but media keys have sadly been relegated to secondary functions of the F-keys.

The Strafe has no dedicated macro keys, but the ability to reprogram almost every key, coupled with the Corsair Utility Engine (CUE) makes up for it. It's notably lacking a decent hardware-only mode, though, as all complex lighting effects and custom key commands need the software, but it's at least easy to import and export settings.

Still, CUE allows for essentially unlimited profiles, which can be linked to programs. Within profiles, you can have modes and you can easily set keys to toggle between them, which is useful if you're playing as different character types within the same game, for example. Assigning functions via the key map is simple too, and you can delve into the Actions manager if you want to get really fancy, where you'll find all manner of options. The macro editor is extremely detailed, even including mouse tracking and inter-device features with other Corsair peripherals. It can be a little overwhelming at first, but you quickly acclimatise to the layout.

The RGB lighting options are just as detailed, with foreground and background and the ability to control how and when patterns are triggered and ended. Keys are easily assigned and saved to groups too – if there's an effect you have in mind, the Strafe RGB can

probably bring it to life. The backlighting is attractive with no major pitfalls – the slight blue tinge to whites and a little bleed into lower symbols are the only concerns.

Conclusion

The Strafe has all the features and customisation of the K70 RGB, but the design isn't as refined, which makes the £145 price tag hard to swallow. The Silent switches are neat, but they won't remain exclusive forever and they aren't game-changing either.

DESIGN	FEATURES	VALUE
34/40	30/35	15/25

VERDICT

Loads of features and quieter switches, but a few design flaws make the price hard to justify.

OVERALL SCORE
79%

/ SPECIFICATIONS

Connection Wired, USB

Cable 2m, rubber

Material Plastic

Switch type Cherry MX Silent (Blue, Brown and Red available)

Backlighting RGB, per-key

Ports 1 x USB 2

Wrist rest Yes, removable

Extras Programmable keys, n-key rollover, media keys, Windows key lock, key removal tool, replacement FPS and MOBA keycaps

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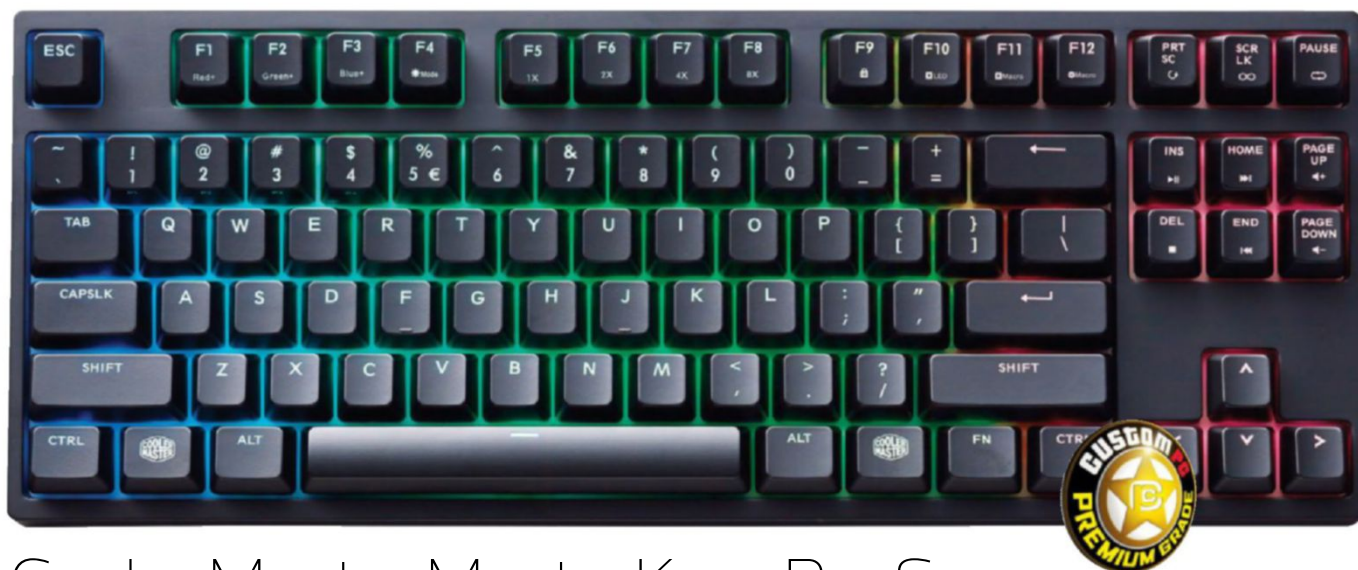
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Cooler Master MasterKeys Pro S / £109 inc VAT (€139)

SUPPLIER TBC

Cooler Master's brand-new MasterKeys Pro S really takes advantage of its lack of a numeric keypad, having no extra keys or bulk and thus a very small footprint. Its minimalist aesthetics will stylistically fit practically anywhere, but belies both the quality of its materials and its surprisingly large feature set.

The smooth, matt plastic is mark-resistant and hefty steel reinforcement means it's robust and reassuringly weighty. It grips smooth surfaces with ease even with its feet extended, and the detachable cable completes the picture of an extremely well-built keyboard.

Beneath each keycap sits a Cherry MX RGB Red switch. These switches are popular with gamers and for good reason – their light, linear action provides a solid feeling of responsiveness. In use, the keyboard emits standard noise levels – considerably more than a membrane or chiclet model, but less than clicky Cherry MX Blue switches. Meanwhile, N-key rollover alleviates any concerns about unregistered key presses.

The MasterKeys has a software package, but unlike the likes of Razer or Corsair's offerings, it's optional rather than essential if you want to access advanced features. The vast majority of the features are all fully accessible via the hardware alone – a respectable approach.

As usual, the FN key is vital, enabling you to unlock secondary functions such as the Windows key lock, repeat rate control, media and volume manipulation and profile switching – in this case, with keys 1–4 (or Esc for the default, macro-free profile). Symbols

for each of these functions are clearly displayed, and when you hold FN, the relevant keys light up white to show your current profile and repeat-rate setting at a glance.

Even the RGB lighting is handled similarly, with F1–F3 handling the red, blue and green channels – and helpfully lighting up in these colours when FN is held – and F4 toggling the current LED mode, of which there's plenty enough to keep you entertained. Like the Quick Fire XTi (opposite), you can also record your own per-key pattern, with the FN key acting as an indicator of your currently selected colour.

The lighting quality is excellent too – a reflective plate provides a lovely flow between keys, which makes the effects very striking and means even dual-symbol keys have a mostly even glow. Meanwhile, macros can be applied to nearly any key in each of the four custom profiles, and the recording method is simple and intuitive.

Playback modes can be chosen but delays are recorded as they're inputted with no option to change them. When macros are playing, the keys being triggered light up white in real time.

The software doesn't expand on the macro capabilities of the MasterKeys Pro S. Instead, it simply allows you to fine-tune the lighting further than the hardware allows.

It gives you precise RGB controls for each LED mode in all four profiles and adds a couple of extras – System Status, where the keyboard can display audio EQ or system load, and Multilayer, where you can combine up to four effects from the other modes – for example, making a custom static pattern

that ripples when keys are pressed. You can also easily back up, import and export your lighting settings.

Conclusion

Cooler Master has focused on maintaining quality at every level of the MasterKeys Pro S and keeping its extensive features easily accessible. More complex macros via software and a wrist rest would be welcome touches, but this keyboard offers the best balance of all the keyboards on test for a reasonable price, and if you need a numeric keypad, we're happy to recommend the £130 Pro L version too.

DESIGN 39/40 FEATURES 25/35 VALUE 20/25

VERDICT

Outstanding design, a solid feature set, enviable simplicity of use and a fair price.

OVERALL SCORE
84%

/ SPECIFICATIONS

Connection Wired, USB

Cable 1.5m, braided, detachable

Material Plastic

Switch type Cherry MX RGB Red (Brown available)

Backlighting RGB, per-key

Ports No

Wrist rest No

Extras Programmable keys, N-key rollover, media keys, Windows key lock, key removal tool, repeat rate adjustment



Cooler Master Quick Fire XT / £130 inc VAT

SUPPLIER www.box.co.uk

The Quick Fire XT has an all-plastic exterior but it's reinforced inside and feels satisfyingly solid. Its cable is detachable too, and it isn't prone to slipping across desks. The chassis is also no bigger than necessary, and there are no extra macro keys making it oversized. It's completely plug and play too, requiring no software, but it still has macro support.

The P1-P4 buttons above the numeric keypad provide access to the four custom profiles. FN-F9 puts the board into macro record mode, at which point any available keys (almost every one) light up blue, while any keys with macros already assigned light up red. Simply select your key, input your commands, choose a playback mode and finish the recording to save the macro. You can also revert to the default profile with FN-Esc.

Only macros can be assigned to keys and delays are recorded as they're made with no ability to change them. Ducky's Shine 5 (see p46) manages to get even more options into a plug and play design, such as delay control and Windows shortcuts, but it involves consulting the manual. Comparatively, Cooler Master's system is instantly easy to understand from the printed symbols alone. The FN key is used for more features too, including all the usual media functions as well as repeat rate adjustments with F5-F8, all of which are clearly marked.



Cooler Master sent us a sample using Cherry MX Brown switches, which make the XT a pleasure to use when typing or gaming. N-key rollover is supported too, although there's no toggle to disable it. The steel base plate also creates a slight twanging echo when larger buttons such as the spacebar and backspace are hit, particularly if you're heavy-handed, but otherwise, noise is standard for a

The LEDs are very
bright and shine
between the
keycaps attractively

mechanical keyboard. A key puller is bundled for easy cleaning, as well as a Cooler Master logo keycap that fits any of the modifier keys on the bottom row (Ctrl, Alt and so on). It's a shame Cooler Master has stopped including wrist rests with its latest keyboards, however.

The XT uses dual-colour backlighting. Each key can display five levels of red or blue, and you can mix them up to make different shades of red, blue and purple. The quality of the backlight is great – the LEDs are very bright and shine between the keycaps attractively, thanks to the reflective plate. Occasionally, some of the purple shades look a little uneven (having more blue in one key than another, or some keys being brighter than other) but it only affects static patterns, and only a little – all the moving patterns look gorgeous.

The FN key again comes into play here – F3 toggles the current lighting mode, while F1 controls the blue level and F2 the red. You can even create your own per-key pattern, which

is again very easy, with the FN key showing the currently selected colour. Your custom colours and per-key patterns are saved in each of the five profiles, including the default one. We promise it isn't as complex as it sounds. Unlike the Shine 5, symbols on the keys aid your memory, although the LED indicator system on the MasterKeys Pro S has been improved even further.

Conclusion

The Quick Fire XT is a mighty fine keyboard, but it's pricey for what it offers, with only dual-colour backlighting and no wrist rest. Cooler Master's own MasterKeys Pro L (the same as the Pro S opposite, but with a numeric keypad) will cost around the same price when it launches, but will have further refinements and full RGB lighting, making it a better deal.

DESIGN 38/40 FEATURES 25/35 VALUE 17/25

VERDICT

Outstanding build quality and a great example of plug and play design, but it's a little too pricey.

OVERALL SCORE
80%

/ SPECIFICATIONS

Connection Wired, USB

Cable 1.5m, braided, detachable

Material Plastic

Switch type Cherry MX Brown (Blue and Red available)

Backlighting Dual-colour (red/blue), per-key

Ports No

Wrist rest No

Extras Programmable keys, n-key rollover, media keys, Windows key lock, key removal tool, repeat rate adjustment, replacement keycap



Ducky Shine 5 / £140 inc VAT

SUPPLIER www.amazon.co.uk

Ducky is a Chinese company with a high reputation for quality, and the Shine 5 shows why. It's built like a brick and the feet and cable are detachable to minimise potential breakages. The dedicated volume and calculator keys in the top right add no bulk and the bezel around the keys is thin. Meanwhile, a lovely brushed-metal effect provides a smart appearance that will suit any environment.

The Cherry MX RGB Brown switches in our sample were great for both typing and gaming, but three other types are available. The keyboard is a joy to use, though there's no wrist rest, and the keycaps strike a good balance between grip and smoothness. There are four switches on the underside. By varying the position of the first three, you can change the position of the FN key to any of the bottom modifier keys (Ctrl, Alt and so on) – a really neat touch, while the fourth switch toggles between n-key and 6-key rollover. A key puller and replacement spacebar are also included, and you can even purchase spacebars with different city skyline imagery.

The Shine 5 is fully plug and play but the number of jobs you can get it to perform rivals and even exceeds many keyboards with

software packages. It has six on-board profiles, including a default one where keys can't be customised. Changing profiles with FN and the 1-6 keys gives you instant LED feedback, and you can set a custom repeat rate and repeat delay settings for each one.

Of course, the key feature is the RGB backlighting. Like the MasterKeys Pro S (see p44), you can flick between the keyboard's numerous single and multi-colour lighting modes and control their RGB properties with three of the F-keys. One really neat feature is that hitting FN-spacebar lights up all the keys in several different colours, allowing you to select the colour you want with a single key tap. You can adjust the speed of any modes that feature movement too, and you can even set two customised zones to static or breathing lights, which will be unaffected by the background mode. Basically, you can create a multi-layered lighting effect without resorting to software.

The Shine 5 also uses two double-layer PCBs, enabling Ducky to mount a larger SMD LED than usual with the Cherry switches. The effect speaks for itself – it's the highest-quality backlight on test, being bright, vibrant and showing convincing whites too.

Reprogramming virtually every key is also possible and, better yet, you can assign each key two custom functions if you wish. Much like Roccat's EasyShift+ feature, the FN key triggers a second function layer when held down. Macros can be recorded with delays in real time, or the delay can be set manually down to a minimum of 0.02 seconds, and there's a variety of playback options too. You can even choose from a host of preset custom functions, such as media control, mouse commands and Windows shortcuts.

The downside is that the keycaps give no indication of their special functions, so you need to spend a fair bit of time with the manual. Cooler Master's plug and play design may be less sophisticated, but its additional keycap symbols and LED indicators make it much easier to understand.

Conclusion

There's no other plug and play keyboard that can match the features of the Shine 5. The lower barrier to entry and cost sees Cooler Master nab our recommendation, but if you can afford the price, and you're prepared to put in the work to get used to it, the Shine 5 remains a fantastic keyboard.

DESIGN 35/40 FEATURES 29/35 VALUE 16/25

VERDICT

A well made and highly functional keyboard with gorgeous RGB lighting, although it's costly.

OVERALL SCORE
80%

/SPECIFICATIONS

Connection Wired, USB

Cable 1.5, rubber, detachable

Material Plastic

Switch type Cherry MX RGB Brown (Black, Blue and Red available)

Backlighting RGB, per-key

Ports No

Wrist rest No

Extras Programmable keys, n-key rollover, media keys, dedicated volume keys, key removal tool, repeat rate/delay adjustment, replacement spacebar



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Logitech G810 Orion Spectrum / £140 inc VAT

SUPPLIER <http://gaming.logitech.com>

The G810 Orion Spectrum follows the G910 Orion Spark but, with its matt black finish and simple design, it has a more grown-up, understated feel. The material picks up fingerprints easily, but it's undeniably solid. The feet can also be set to two different heights, which is useful, as the G810 feels flat without them.

The key feature is the set of Romer-G switches. With a 45cN actuation force and tactile feedback, the closest comparison is Cherry MX Browns and, after spending some time with the Romer-G switches, we've become big fans of them. They feel fast and responsive, and the subtle feedback is appreciated when typing. The action consistency is good too, the keycaps are pleasantly shaped and it's easy to glide your fingers around them. Gaming is just as good too; fast, repeated taps don't feel hindered.

The keys have noticeably less total travel than Cherry switches, although we didn't notice a difference in the actuation point. A clear difference is noise, however; the G810 is considerably quieter than most of the keyboards on test. We can't say these switches are better than Cherry ones, but they're just as good and a viable alternative. Similarly, 26-key rollover is just as good as n-key, practically speaking. There are notable omissions from the feature set, though, with no USB ports or wrist rest, for example.

The G810 also sports dedicated game mode, RGB lighting and several media keys, including a volume wheel, all of which have a good action. There's no secondary function key, nor any dedicated macro keys, but all 12 F-keys can be assigned as macros through the software. The G810 is fully dependent on this software for any tweaking other than

basic plug and play effects though – no settings can be saved to the hardware.

Thankfully, the Logitech Gaming Software (LGS) is fast and user-friendly. The homepage presents a simple key map with the function, gaming and lighting keys glowing ready with the relevant sub-menu. LGS scans your system for almost 600 games, each of which has a set of pre-made commands that you can assign to the F-keys. Naturally, you can add your own games and commands too; the

You can create your own per-key static colour patterns

macro editor is missing a couple of minor features but it's still powerful and intuitive.

You can create as many profiles as you like, tying them to one or more games or having multiple profiles per game – the G810 really makes the most of having just 12 programmable keys. Each profile has a game mode, which is activated with the dedicated button. This mode not only disables the Windows key, but also any other keys you choose. Other features include a heat map and stat tracking (which is off by default).

Meanwhile, the backlight button can only turn the LEDs on or off, but each profile can be customised with one of three LED modes. The complexity is nowhere near that of Razer or Corsair's lighting systems, but there's a solid selection of effects, you can create your own per-key static colour patterns and even the lock indicators feature RGB LEDs. Alternatively, certain games can control the

lighting for game-specific effects. With the LEDs centred beneath the keycaps, the lighting on each key is extremely even, although your viewing angle has an influence too. There's no bleed between the keys, and white lighting has a slight blue tinge from the colour of the switch housing.

Conclusion

The G810 wins our favour with its understated design, solid build quality and Romer-G switches. It doesn't offer the most complex customisation features, but the software is excellent and it does its job well. It's a solid keyboard if you don't mind a software-driven approach, but its high price and comparatively slim feature set see it miss the sweet spot.

DESIGN **37/40** FEATURES **23/35** VALUE **15/25**

VERDICT

Well crafted hardware and software, but it's too expensive for its limited feature set.

OVERALL SCORE
75%

/ SPECIFICATIONS

Connection Wired, USB

Cable 1.8m, braided

Material Plastic

Switch type Romer-G

Backlighting RGB, per-key, game-controlled

Ports No

Wrist rest No

Extras 12 macro keys (0 dedicated), 26-key rollover, dedicated media keys, Windows key lock

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Roccat Ryos MK FX / £140 inc VAT

SUPPLIER www.amazon.co.uk

Roccat's Ryos MK FX is the largest keyboard on test, partly because it has both a left column of five macro keys, as well as three macro keys below the spacebar. They're all very convenient to reach from a standard WASD position, but they're also flat and stiff in order to prevent accidental actuation. In addition, the Ryos MK FX has a wide trim around the keyset, including a built-in comfortable wrist rest, although it's sadly not detachable. Like the K70 RGB, the Ryos also needs two USB ports for power alone, probably because it contains two ARM Cortex CPUs, so there's no USB pass-through, but analogue audio pass-through sockets are easily accessible in the top left.

With its Cherry MX RGB Brown switches and n-key rollover, the Ryos provides a first-class typing and gaming experience, and excellent grip too. However, while the Ryos is robust, the plastic doesn't have the look or feel you expect for £140, and the small glossy section is prone to picking up marks.

Where the Ryos excels is when it comes to customisation. There's the usual FN button and associated additional functions such as media control, but Roccat takes secondary functions further than anyone else with EasyShift+, which replaces Caps Lock (although Caps Lock can be restored via software). Hold it down, and every other key has an extra programmable utility. If you have a compatible Roccat mouse, the two devices can act as EasyShift+ triggers for each other. While custom bindings and the RGB lighting are managed through Roccat's Swarm

software, the Ryos MK FX has a whopping total of five on-board profiles, enabling you to take masses of settings with you anywhere.

In most areas, the software rules the roost for usability. Settings are neatly categorised and logically laid out in boxes, any of which you can easily pin to a favourites page for quick access. The profile manager makes swapping profiles in and out of the keyboard's memory simple too, and the software also enables auto-swapping based on the current program or game that's running.

Key assignment is dead simple with the key map, and there's an impressively extensive list of pre-made macros, which conveniently includes modern games such as CS:GO, Dota 2 and League of Legends, as well as programs such as Skype, Photoshop and Firefox. Custom macros are easy to make and manage too, while basic mouse functions and delay customisation are also supported, although a few playback options are missing.

Finally, full keyboard RGB effects can be configured easily enough, although the more advanced, per-key patterns are the only area where the software stumbles a little and isn't as easy to use nor as in-depth as Razer's, for example. Also, the Thumbster keys below the spacebar have white rather than RGB LEDs. That said, the keyboard does support TalkFX and AlienFX, allowing games to take over the lighting with feedback effects. The biggest problem with the lighting is the quality. It's bright and evenly lit, but transitions between colours in moving patterns can stutter and be distractingly obvious.

Conclusion

This last point is a bit of a problem, since the lighting is arguably the whole point of paying the premium for this keyboard, preventing the Roccat from getting an Extreme Ultra award. That said, with its eight macro keys, an entire layer of secondary functions and five on-board profiles, the Ryos reaches beyond any other keyboard on test in terms of customisation, and it's very easy to configure. The RGB lighting may be improved with future firmware or software updates, but for now, it narrowly misses the mark for this price.

DESIGN 32/40 FEATURES 33/35 VALUE 16/25

VERDICT

Great customisation and software, but the materials and lighting lack the quality implied by the price.

OVERALL SCORE
81%

/SPECIFICATIONS

Connection Wired, 2 x USB

Cable 1.8m, braided

Material Plastic

Switch type Cherry MX RGB Brown

Backlighting RGB, per-key, game-controlled

Ports Headphone, mic

Wrist rest Yes

Extras 8 dedicated macro keys, programmable keys, EasyShift+, n-key rollover, media keys, Windows key lock



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Razer BlackWidow Chroma Stealth / £140 inc VAT

SUPPLIER www.amazon.co.uk

Razer's core BlackWidow design is very familiar now – it's a little bulky down the bottom but not excessively. The smooth, matt plastic on this Chroma edition resists grubby fingers well, and you can tell the keyboard is well reinforced too. Likewise, the captive cable is rigidly attached – a necessity given the extra connections needed to serve the handy pass-through ports.

Razer's mechanical keyboards use either its Stealth (orange) or Clicky (green) switches. Kailh manufactures them, but Razer has a hand in the design and its own QA staff oversee production. The Stealth switches here have a 45cN actuation force and a tactile bump, similar to the Cherry MX Brown design. Razer claims to have made improvements in actuation point (1.9mm compared to 2mm) and longevity (60 million presses compared to 50m), but these numbers are of little consequence – it's the feel that matters.

Thankfully, the Chroma Stealth feels great. Consistency is as good as we'd expect and the switches are suitably light. Next to Cherry MX Browns, the actuation force and distance are difficult to tell apart, but the bump in the Razer switches is more pronounced, both on the way down and up.

We found riding the actuation point for quick double taps a little easier on Cherry switches, but otherwise the difference was negligible. The keycap surfaces are well refined too, and while the BlackWidow is only officially rated for ten-key rollover, it can often register more presses than ten, so missed commands won't be a problem.

Meanwhile, the left column of five macro keys are fine for hitting quickly, but they're not

as well positioned as Roccat's Thumbster keys below the spacebar. Other hardware functions, usable with the FN key, include media control, on-the-fly macro recording, a gaming mode, brightness control and system sleep.

More advanced features rely on Razer's Synapse software, which has an annoying requirement for online account creation. Still, it's a quick process and you can then remain offline forever. No settings can be saved to the keyboard though – you'll have to install Synapse and import settings (locally or via the cloud) if you take your keyboard anywhere.

As such, it's great that the software is extremely slick and well designed. Like Logitech's software, it can allow games to control the on-board lighting and it can track your stats (off by default). You can also set Gaming Mode to disable more than just the Windows key, and its key and lighting options far exceed those of most other brands.

A key map and dropdown menus make programming keys with custom functions a cinch. Macros, program launching, profile switching and inter-device functions, among other features, are all available. Practically all the keys can be configured and you have essentially unlimited profiles that you can easily assign to specific games. Macro recording is just as intuitive and also powerful, giving you mouse commands (not movement) and all the standard delay and playback options.

Meanwhile, basic full keyboard lighting patterns such as waves and reactive typing can be applied and customised in mere seconds. More complex, per-key patterns can be assigned in the Chroma Configurator,

which lets you create your own zones and stack layers of effects on top of one another – the whole process is kept admirably simple.

The reflective plate inside the keyboard ensures the lighting is really attractive too – the BlackWidow Chroma Stealth rivals Cooler Master's latest keyboards for quality in this area.

Conclusion

The BlackWidow Chroma Stealth has plenty going for it. The Corsair K70 RGB has a more refined design, making it our favourite premium keyboard, but this slightly cheaper effort from Razer is still a very worthy alternative.

DESIGN 35/40 FEATURES 30/35 VALUE 16/25

VERDICT

A solid high-end keyboard with a strong feature set and excellent software.

OVERALL SCORE
81%

/ SPECIFICATIONS

Connection Wired, USB

Cable 2m, braided

Material Plastic

Switch type Razer Silent (Clicky available)

Backlighting RGB, per-key, game-controlled

Ports 1x USB 2, headphone, mic

Wrist rest No

Extras 5 dedicated macro keys, programmable keys, 10-key rollover, media keys, Windows key lock

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Razer BlackWidow Ultimate 2016 / £100 inc VAT

SUPPLIER www.cclonline.com

The Razer BlackWidow Ultimate 2016 uses Razer's Clicky switches, which are based on the Cherry MX Blue design but have a higher actuation point and longer lifetime rating. The experience is very similar, however, with a just as distinctive and satisfying a click. Razer's tactile feedback is again more noticeable, especially when the key resets, which can occasionally be mildly distracting, but if you generally like a solid click from your switches, you'll like these ones.

Build quality is a little lower than that of the more expensive Chroma – the textured plastic is less luxurious, but the keyboard is still strong, with good grip and a reinforced connection for the braided cable. USB and audio pass-through connections are included on the right, but oddly, Razer has opted for a mobile-style single audio jack instead of the usual split headphone and microphone ports, with no Y-cable provided.

The keyboard sports classic green backlighting and, with a green reflective plate beneath the keys, the effect is captivating. You



get a very even, bright glow with zero bleed on dual-symbol keys, on which the lower characters are printed, rather than etched, but are still legible. Gaming mode is triggered with FN-F10, locking the Windows key. FN also enables media keys and brightness control, but any other tweaks require Razer's Synapse software, which requires you to register for an online account.

If that requirement doesn't bother you, you'll be greeted with a seriously slick and intuitive experience. The Ultimate 2016 may not have the five macro keys of its Chroma

brethren, but you can have as many profiles as you like and easily reprogram nearly every key with almost any function, including your own custom macros via the powerful editor. Profiles can be tied to games and settings are stored in the cloud (offline import and export is supported too). There are stat tracking options too, which are off by default.

Even the per-key lighting editor is deep, albeit without colour options. Instead, you can work with different brightness settings of green – it's as detailed as single-colour backlighting gets.

QPAD MK-90 / £100 inc VAT

SUPPLIER www.box.co.uk

The MK-90's £100 price is attractive for a mechanical, RGB keyboard. The MK-90 even has a comfortable, detachable, soft-touch wrist rest, a keycap puller, and dual USB 2 and audio jack pass-through ports. These ports are at the back, but printed markings make finding them easy. The MK-90 also has respectable, if not outstanding, build quality, and the soft-touch material isn't a fingerprint magnet.

The Kailh switches feel spongier than the Cherry Reds they're designed to mimic, though, lacking the proper light, clean and precise feel – the variation is very clear when using them side by side. Ultimately, if you're coming from a membrane keyboard, it's a clear and worthy upgrade, but you'll be underwhelmed if you're used to Cherry switches. Thankfully, there are no issues with consistency or the keycaps themselves.

The hardware itself is easy to use: the n-key/6-key rollover toggles, media functions, repeat rate adjustment and lighting

control are all handled with the FN key and are clearly labelled. There are also five on-board custom profiles, as well as a default one.

Meanwhile, the lighting has four brightness levels, with even lighting both through and between keycaps – only the big Q logo on the spacebar isn't quite fully lit. Whites look good too, if a little blue, and colour transitions are smooth.

While almost every key can be customised, though, QPAD's software is poor. The layout is awkward, and it's also slow and a little buggy. Macros can't record mouse clicks, nor can you set a delay of less than 50ms.

There isn't even a separate macro manager – you have to re-record every time you want a new one. You do at least get a key map to track custom functions.

As for lighting, each profile has eight tuneable patterns, as well as a custom, per-key pattern. However, even selecting and deselecting keys is fussy and awkward. The lighting isn't that complex either, although frankly, that's just as well given the usability of the software. The MK-90 is a good example of a keyboard trying to do too much and ending up doing some jobs poorly as a result. It's a shame, because from a



For £40 less than the Chroma, you lose the macro keys and RGB lighting, but functionally, the two keyboards are otherwise the same. The result is a great value mechanical keyboard, especially if you want to tweak your keyboard on a per-game basis.

DESIGN 34/40 **FEATURES** 27/35 **VALUE** 21/25

VERDICT

Great single-colour backlighting, software and pricing make this a great value keyboard.

OVERALL SCORE
82%

/SPECIFICATIONS

Connection Wired, USB

Cable 2m, braided

Material Plastic

Switch type Razer Clicky (Silent available)

Backlighting Green, per-key, game-controlled

Ports 1x USB 2, headphone/mic combined jack

Wrist rest No

Extras Programmable keys, 10-key rollover, media keys, Windows key lock

hardware perspective, the keyboard is mostly well designed. The software required to unlock many of the extra functions is a mess, though, and QPAD needs to step up its game in this area.

DESIGN 26/40 **FEATURES** 30/35 **VALUE** 19/25

VERDICT

A good feature list for the price, but the Kailh switches and poor software let it down.

OVERALL SCORE
75%

/SPECIFICATIONS

Connection Wired, USB

Cable 2m, braided

Material Plastic

Switch type Kailh Red

Backlighting RGB, per-key

Ports 2x USB 2, headphone, mic

Wrist rest Yes, removable

Extras Programmable keys, n-key rollover, media keys, Windows key lock, key removal tool, repeat rate adjustment



Tt eSports Poseidon Z RGB / £84 inc VAT

SUPPLIER www.cclonline.com

Getting a mechanical, RGB-backlit keyboard for under £90 is almost unbelievable, yet the Poseidon Z RGB manages this feat, and it's pretty well built too. The smooth, matt black plastic and small profile mean it's also aesthetically inoffensive, and the grip is good too. The cable is flimsy, and there are no extras in the box, but you can't ask for everything for this price.

Meanwhile, the Tt-Certified Brown switches are Kailh's version of Cherry MX Browns with Tt eSports' seal of approval. The action isn't as smooth as Cherry's, the consistency isn't as high and the bump is more pronounced, but the differences are subtle rather than drastic. The keycap surfaces offer no qualms either, and n-key rollover is present too.

Hardware features are solid as well – the indicators in the top-right corner aid usability and all the regular FN-based commands are present, as well as profile switching and on-the-fly macro recording. On top of the default profile, you can choose from five customisable profiles, in which all the keys except Windows and FN can be rebound; a decent way to make up for the lack of dedicated macro keys. Key functions are limited to macros, single key remaps or program launching. It's also handy that you can set Shift, Ctrl and Alt to quickly switch profile in the heat of battle. Unlike the QPAD MK-90 (see opposite), the Poseidon Z RGB also gives you a separate macro editor, which is very functional and sports all the delay and playback options you expect.

Meanwhile, the lighting controls include a small selection of the usual patterns and effects, enabling you to change certain elements such as speed and direction, as well as colour. Only one layer and effect can

be active at a time, but it's programmable on a per-key basis. The lighting itself is okay, but not exceptional – the underglow between keys could definitely be more even and dual-character keys are only partially lit. Whites are also a little on the blue side. While the software is better overall than that of QPAD, it definitely isn't as intuitive, deep or slick as many of the

other systems on test. Settings are also a little slow to apply, so there's definitely room for improvement.

The Poseidon Z RGB isn't the best keyboard in any area, but it has no

major pitfalls either, and it's surprisingly capable for the money. If you really want some mechanical RGB action, but don't have a flush wallet, the Poseidon Z RGB will give you the basics.

The indicators in the top right corner aid usability

DESIGN 30/40 **FEATURES** 26/35 **VALUE** 23/25

VERDICT

Surprisingly good quality for an attractive price, despite a few compromises.

OVERALL SCORE
79%

/SPECIFICATIONS

Connection Wired, USB

Cable 1.8m, rubber

Material Plastic

Switch type Tt Certified Brown (Blue available)

Backlighting RGB, per-key

Ports No

Wrist rest No

Extras Programmable keys, n-key rollover, media keys, Windows key lock



SteelSeries Apex M800 / £145 inc VAT

SUPPLIER www.overclockers.co.uk

In a group of high-quality keyboards, the Apex M800 lacks the premium feel of many of its competitors. It isn't weak or flimsy – just lacklustre; the textured black plastic is run-of-the-mill and it could really do without the glossy black trim around the keys, which just gets smudged immediately. The cable is also fixed and has no reinforcement at the connection. The swappable rubber feet that lock into place are great though – grip is flawless.

The QS1 switches have only 3mm of travel and SteelSeries uses very low-profile keycaps, creating a flatter keyboard than usual. The surfaces of the keycaps are aligned on a single plane, which aids typing speed and improves the feeling of responsiveness. It's also a very quiet keyboard, rivalling the Strafe RGB Silent in this regard.

Unfortunately, we ran into consistency issues with our sample; some keys were noticeably heavier to actuate than others. Mileage will vary in this respect – some people might rarely notice it, while others might find it irritating – it could potentially result in accidental missed key presses. The actual action of the keys is mostly fine, although they feel spongier than Cherry or Romer-G switches and they're not strictly linear either – you can detect a small bump at the reset point if you pay deliberate attention.



Despite some criticisms, the switches are still good, as is the keycap design – once you're used to it, you can really fly around the keys. However, it does look as though SteelSeries needs to refine its sorting processes.

Replacement keycaps with Apple keyboard symbols are also supplied, but oddly, no key puller is included. There's no wrist rest either, but the keyboard is still comfortable to use with either set of feet.

In terms of hardware control, holding FN reveals, via backlighting, the keys with secondary functions, including the Windows key, which acts as its own lock (but has no indicator when locked). You can also control backlight brightness and media playback. Mostly though, the Apex M800 is reliant on SteelSeries' Engine software. It does have an on-board profile, but it lacks the capacity for macro execution, so it's pretty limited. Through Engine, you can have limitless profiles tied to games or programs. These profiles can be stored in the cloud, and without forcing you into making an online account.

Thankfully, the software is among the best. Key bindings are extremely easy to assign with the key map, and all keys are open to programming, not just the six macro ones. There are no obvious omissions in the functions available, and the macro editor is fast and intuitive with no missing delay or playback options.

Meanwhile, lighting options include active and idle modes, with effects for both modes fully customisable, as well as the idle time delay. There's a handy selection of templates supplied, and creating your own patterns is pretty simple too. The lighting control isn't on the same level as that of Razer or Corsair, but it will certainly keep most people happy.

Game-activated lighting is also supported via GameSense, although the selection of games is small. The lighting quality is very good too, thanks to the centre-mounted LEDs – the brightness only tails off a little at the very bottom of dual-symbol keys.

Conclusion

While the SteelSeries Engine software is on point, the company needs a little more refinement on the hardware side if it's going to charge £145 for this keyboard. The QS1 switch isn't perfect, but it's promising – hopefully, we'll see SteelSeries continue to develop its switches further. In this price league, though, Razer's BlackWidow Chroma and Corsair's K70 RGB offer superior quality.

DESIGN	FEATURES	VALUE
32/40	31/35	15/25

VERDICT

Excellent software, but it lacks the necessary hardware for a perfect premium package.

OVERALL SCORE
78%

/ SPECIFICATIONS

Connection Wired, USB

Cable 2m, braided

Material Plastic

Switch type SteelSeries QS1

Backlighting RGB, per-key, game-controlled

Ports 2x USB 2

Wrist rest No

Extras 6 dedicated macro keys, programmable keys, n-key rollover, media keys, Windows lock, replacement keycaps



Xtrfy XG1-R LED / £114 inc VAT

SUPPLIER www.overclockers.co.uk

Xtrfy's XG1-R LED opts for quality and simplicity over a massive feature list. It's a respectable approach, but it still needs to justify its £114 price tag. The deal isn't sweetened by any extras or accessories, but from a build quality perspective, the XG1-R LED impresses – the matt black plastic feels solid and the board is robust at all points, including the flick-out legs, and the cable is detachable too. Grip, however, is a little weak on the left side, but it's much improved with the legs up.

Meanwhile, the use of Cherry MX Red switches ensures a smooth, consistent and linear action for every key. Noise is no louder or quieter than you would expect, and larger buttons don't produce a loud echo like they can elsewhere. The switches aren't the RGB variety though; the XG1-R LED has white backlighting. As usual, the backlight is focused through the top half of the keycap, but since the dual-character keys have both symbols printed on the top half of the keycaps, there are no issues with partially lit keys. The lock keys, including the Windows-locking G-key, also have red LEDs to function as indicators, and there are dedicated volume keys too.

FN-Esc is used to turn the lighting on or off, while pairing FN with the 12 F-keys offers control of the brightness and patterns, with handy symbols printed on the chassis so you don't have to commit the functions to memory. There's a good selection of effects, our favourite of which are the equaliser ones, which react to external sound, rather than system sound.

In the name of simplicity, the XG1-R LED is fully plug and play, requiring no software. It

still has some macro features, although they're limited in comparison with most of the other keyboards on test. Only the eight QTLA macro keys at the top are programmable, and there's only one on-board profile. QTLA stands for Quick, Timing, Auto, Loop, referring to the four playback modes available. Of the eight keys, three are Quick (no delays, single playback) and three are Timing (delays

The Cherry MX Red switches are smooth, consistent and linear

recorded, single playback), while Loop (delays recorded, playback until pressed again) and Auto (holds down key(s) until pressed again) have one key each. It's an odd but logical approach, and the macro recording/deleting process is quick and easy to grasp. Also, the Loop and Auto keys will execute macros uninterrupted by other key presses.

There's also a neat touch in the form of a sticker on the back that reminds you how to record macros, adjust the repeat rate speed and switch LED settings. The only major issue is the position of the macro keys – they're positioned out of the way, so they're not easy to hit quickly while playing.

The FN key is also positioned out of the way, but it isn't a key you'll need to hit with any urgency while gaming.

Also, it functions as Esc if you press it but don't combine it with anything (it triggers Esc at the reset point, not the actuation), which

could be a handy feature, as you may accidentally hit it instinctively when looking for the actual Esc key. Similarly, any macro key left at its default setting will function as whatever F-key it's positioned above.

Conclusion

There's nothing wrong with offering a keyboard that focuses on a high-quality, no-nonsense design, as many people don't need RGB lighting or lots of customisation options. However, in this case, the price is simply too high for what's on offer, especially compared with Cooler Master's latest plug and play keyboards. **CPC**

DESIGN	FEATURES	VALUE
36/40	20/35	17/25

VERDICT

A solid design, but it needs a price drop to compete with newer plug and play keyboards.

OVERALL SCORE
73%

/ SPECIFICATIONS

Connection Wired, USB

Cable 1.7m, braided, detachable

Material Plastic

Switch type Cherry MX Red

Backlighting White, per-key

Ports No

Wrist rest No

Extras 8 dedicated macro keys, n-key rollover, media keys, dedicated volume keys, Windows key lock, repeat rate adjustment

PC system reviews

GAMING PC

PC Specialist Nova / £1,999 inc VAT

SUPPLIER www.pcspecialist.co.uk

P PC Specialist has named its Nova after an intergalactic explosion, so we're expecting a lot from this sturdy, squat system. It starts well with a Zotac GeForce GTX Titan X. It's Nvidia's beefiest graphics card, with the same Maxwell architecture used elsewhere but with almost three billion more transistors than the GTX 980. That translates to 3,072 stream processors, a 1GHz core, and 12GB of GDDR5 memory clocked to 1753MHz.

The Titan X punts the PC Specialist into the £1,999 tier of gaming PCs. CyberPower's Infinity X77 Deluxe has a GTX 980 Ti GPU, which performs similarly to the Titan X for a significantly cheaper price, while the Chillblast Fusion Hellfire has two overclocked GTX 980 cards.

CPU power comes from a quad-core i7-6700K overclocked to 4.6GHz. That's the same chip as the CyberPower, although there it ran at 4.7GHz. The outlier is the Chillblast, which deployed a 6-core Core i7-5820K with a 4.2GHz overclock. The Nova's third high-end component is its Intel 400GB 750 Series SSD, which sits in a PCI-E slot. It's similar hardware to rivals: the CyberPower has the

same SSD, and it isn't far removed from the Chillblast's Samsung M.2 drive. You also get a 2TB hard disk and 16GB of 3000MHz DDR4 memory.

The components attach to an Asus Maximus VIII Ranger. It's a subtle-looking board littered with features: power and reset buttons, plus a POST display, sit at the top and bottom, and the SupremeFX audio circuitry is shielded to prevent interference. There's also an M.2 slot and plenty of upgrade room – three 1x PCI-E slots and one 16x PCI-E slot lie fallow.

Meanwhile, the Corsair Carbide Series Air 540 case mixes the unusual with the conventional. It's a big, dark box that shows off matt steel with slatted and meshed detailing, and its interior layout is a departure from conventional ATX enclosures. The motherboard tray divides the 332mm-wide chassis down the middle, with a large rear section. This arrangement enables PC Specialist to install the modular Corsair RM850 PSU behind the motherboard tray, along with most of its cables and the optical drive, and there's a four-drive SSD cage around the back too.

The spacious motherboard tray keeps components and cables hidden, making the visible half of the machine clean and smart.



The cables are unobtrusive, and the neat build is showed off by the large window and white strip light.

The middle of the machine is dominated by the Titan X, with the Intel SSD below it, and the cooling tubes from the Corsair Hydro H100i GTX cooler above it. Build quality is sturdy, and the entire system looks good – it's unfussy and well-made, with strength and sensible design throughout.

The Nova has a three-year labour warranty that also includes a year of parts coverage and a month of collect and return service. That isn't as good as the deals included with other systems: the CyberPower has two years of parts coverage, and the Chillblast PC has a five-year warranty with two years of collect and return protection.

Performance

The Nova's 47fps minimum in Crysis 3 at 2,560 x 1,440 is great for a single-GPU machine, although it couldn't quite manage a playable frame rate in this game at 4K. The Nova also returned a 31fps minimum in Fallout 4 at 4K with High detail, and it can cope with the game at Ultra settings at 2,450 x 1,440 too. Strangely, though, it struggled at 4K with Ultra settings in Fallout 4 – a feat that GT 980 Ti machines such as the Overclockers Titan Finesse Phoenix (see p60) can manage – which we assume must be down to a driver issue somewhere. On the plus side, the Nova hit an excellent minimum of 37fps in The Witcher 3 at 4K with High detail, and still ran at 28fps with Ultra settings.

There's no doubting the Titan X's power, but a GeForce GTX 980 Ti card will perform similarly. We've changed a couple of our game tests since reviewing the CyberPower Infinity X77 Deluxe, but its Crysis 3 results are very close to those of the Nova. Meanwhile, the dual-GPU Chillblast returned a playable 33fps minimum Crysis 3 at 4K. The Nova has the benefit of being a single-GPU system, so there's no worry about whether your games will properly work with SLI or not, but the Titan X also pushes up the price.

Meanwhile, in our application tests, the Nova's image editing score of 65,113 beats the 47,023 from the Chillblast,

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.6GHz

Motherboard Asus Maximus VIII Ranger

Memory 16GB Corsair Vengeance 3000MHz DDR4

Graphics Zotac GeForce GTX Titan X 12GB

Storage 400GB Intel 750 PCI-E SSD; 2TB Western Digital Black hard disk

Case Corsair Carbide Series Air 540

Cooling CPU: Corsair Hydro H100i GTX with 2 x 120mm fans; GPU: 1x 70mm fan; front: 2 x 140mm fans; rear: 1x 140mm fan

PSU Corsair RM850 850W

Ports Front: 2 x USB 3, 2 x audio; rear: 2 x USB 3, USB 3.1 Type-A, USB 3.1 Type-C, 2 x USB 2, Gigabit Ethernet, 1x PS/2, 5 x audio, optical S/PDIF

Operating system Microsoft Windows 10 Home 64-bit

Warranty One year parts and labour, plus two years labour only, return to base with first month collect and return

- 1 **Nvidia's top-end GTX Titan X GPU handles gaming duties**
- 2 **The 400GB PCI-E Intel 750 SSD gives you a super-fast boot drive**
- 3 **The Corsair H100i GTX does a great job of cooling the overclocked CPU**

as this test relies on single-core speed, but it's behind the CyberPower's 68,900 with its higher overclock. The Nova's video encoding score of 323,798 is also behind the Chillblast with its six cores. Despite these differences, though, the Nova's overclocked CPU offers competitive performance – unless you're running seriously heavily multi-threaded software, it will be plenty fast enough for your needs.

The Intel SSD also raced through our sequential read and write tests with speeds of 2,070MB/sec and 920MB/sec respectively, being significantly quicker than a SATA drive. We have no qualms about the PC Specialist's thermal performance either; its CPU delta T of 48°C is particularly excellent for an overclocked CPU, and the Titan X peaked at a decent 60°C. The noise wasn't bad either. The Nova is quiet when it isn't tasked with games, and it's only a little louder when pelting through tough titles – its noise output is a low, consistent rumble that isn't distracting.

Conclusion

The Nova is a well-built and well designed PC, but while the Titan X graphics card provides serious bragging rights, it pushes up the price while only delivering modest gains over a GTX 980 Ti. For the same price, the CyberPower Infinity X77 Deluxe offers similar gaming performance, a higher CPU overclock and a very snazzy In-Win 805 case. The

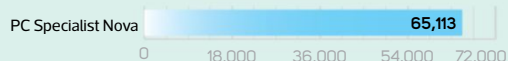


Nova offers better value on paper, but the CyberPower offers better value for money when it comes to results.

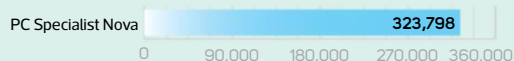
The Nova also can't overhaul the Chillblast Fusion Hellfire. That machine's 6-core CPU is quicker in multi-threaded software, and its pair of overclocked GTX 980 cards outpace the Nova in games. The PC Specialist Nova system is an impressive rig that does little wrong, but the strength of its competition and the unnecessary cost of the Titan X graphics card means it just falls short of a recommendation.

MIKE JENNINGS

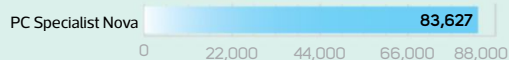
CPC REALBENCH 2015 GIMP IMAGE EDITING



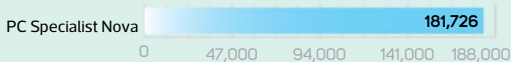
HANDBRAKE H.264 VIDEO ENCODING



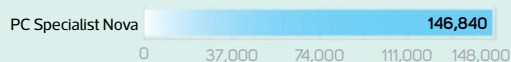
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 128.3%

SPEED
23/25

HARDWARE
22/25

DESIGN
21/25

VALUE
19/25

OVERALL SCORE

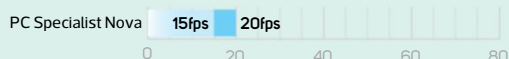
85%

FALLOUT 4

2,560 x 1,440, Ultra Detail, TAA

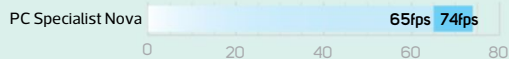


3,840 x 2,160, Ultra Detail, TA

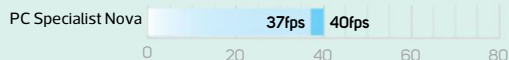


WITCHER 3

2,560 x 1,440, High Detail, AA on, HairWorks off

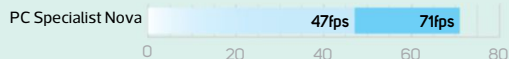


3,840 x 2,160, High Detail, AA on

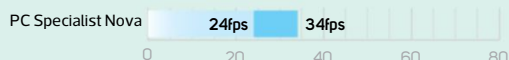


CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

VERDICT

Fast and well built, but the Titan X pushes up the price unnecessarily, meaning you can get a better balance elsewhere.

GAMING PC

Overclockers Titan Finesse Phoenix / £1,667 inc VAT

SUPPLIER www.overclockers.co.uk

The Titan Finesse Phoenix has a consistent red and black theme. The NZXT Noctis 450 case is black throughout, and Overclockers has cleverly made it glow with crimson. There are strip lights in the roof, fans that illuminate meshed areas and more lights under the chassis to provide a warming red glow from beneath. The colouring continues to the components. The Asus motherboard and MSI graphics card both have black heatsinks tinged with red, and the visible power cables are braided in both colours.

The Noctis 450 is practical too. The smart shroud on the bottom of the interior keeps the PSU and its cables hidden, while also providing two spare 2.5in bays. Meanwhile, a slab of metal at the front hides four empty drive bays that can be reached by removing the rear panel. The rubber-lined cable-routing holes also enable Overclockers to keep the build neat and tidy, and the case is well built. The raised plastic used to form the Noctis' angular raised sections never budges, and there's only a little give in the side panels.

Meanwhile, gaming power comes from an MSI GeForce GTX 980 Ti card that includes three performance modes with various speed tweaks. Overclockers has gone one better, though, by raising the core to 1240MHz and the 6GB of GDDR5 memory to 1903MHz (7612MHz effective) – higher than any of the card's preset options.

The Core i7-6700K CPU has also been overclocked from 4GHz to 4.6GHz, which is a solid overclock, especially

considering that there's no liquid cooling. Instead, the CPU is cooled by a large Alpenföhn Matterhorn air cooler. The rest of the Phoenix's specification is pleasingly familiar. There's 16GB of 3000MHz DDR4 memory, and storage is split between a Samsung SM951M.2 SSD and a 2TB hard disk. The 128GB boot drive will have better speed than SATA drives, although it's a shame there isn't 250GB of solid state storage space. You also get a superb Super Flower Leadex Platinum 850W PSU, which is both quiet and exceptionally efficient.

Then there's the Asus Z170 Pro Gaming motherboard, which is a solid choice, offering SLI support and a pair of 1x PCI-E slots for future upgrades. Its audio chips are also isolated from the rest of the circuitry to prevent interference, and its backplate has USB 3.1 Type-A and Type-C connectors alongside more conventional ports. It's a solid, well-featured board that only misses out on enthusiast-level additions; there aren't any buttons or on-board POST displays, and it doesn't have snazzy-looking heatsinks.

Finally, the warranty gives you two years of the all important parts coverage, with a collect and return service, and that's followed by a further year of labour only return to base cover.

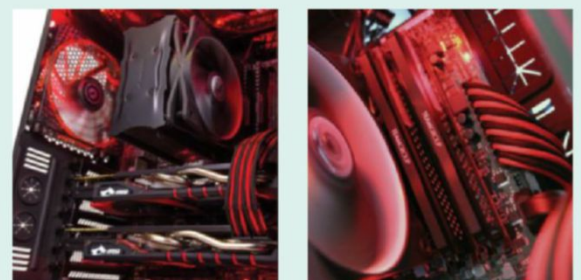


Performance

The overclocked GTX 980 Ti proved adept in games benchmarks. It flew through Fallout 4 at 2,560 x 1,440 with the game's Ultra settings, and it delivered a decent minimum of 28fps with the game running at 4K – a solid result that means the title will be borderline playable.

The Phoenix was even faster in The Witcher 3. The machine's 2,560 x 1,440 minimum frame rate of 79fps is butter-smooth, and it ran through the game's 4K benchmark at 42fps – another top-notch result that could even give you the headroom needed to enable advanced features such as HairWorks. In short, this £1,667 machine can convincingly handle 4K gaming – only minor graphical tweaks will smooth out stutters in the toughest of titles, and that means there's ample power for VR in the future as well.

The CPU is no slouch either. Its image editing score of 66,742 is about right for a 4.6GHz Core i7-6700K, and the video encoding score of 328,834 is solid too – 6-core machines are quicker, but the 6700K's Hyper-Threading support gives it an edge in this test over the Core i5-6600K. The Phoenix returned an overall score of 151,939, which is a



/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.6GHz

Motherboard Asus Z170 Pro Gaming

Memory 16GB 3000MHz Team Group Dark Pro DDR4

Graphics MSI GeForce GTX 980 Ti 6GB

Storage 128GB Samsung SM951M.2 SSD; 2TB Seagate Barracuda hard disk

Case NZXT Noctis 450

Cooling CPU: Alpenföhn Matterhorn with 1x 120mm fan; GPU: 2x 100mm fans; front: 3 x 120mm fans; rear: 1x 140mm fan; top: 3 x 120mm fans

PSU Super Flower Leadex Platinum 850W

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 4 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 2 x USB 2, 1 x PS/2, Gigabit Ethernet, 5 x audio, optical S/PDIF

Operating system Microsoft Windows 10 Home 64-bit

Warranty Two years parts and labour collect and return, followed by one year labour only return to base

- 1** The MSI GeForce GTX 980 Ti makes 4K gaming possible
- 2** The boot drive is a super-fast Samsung SM951M.2 SSD
- 3** A large Alpenföhn Matterhorn cools the CPU with airflow

great result. The Samsung SM951SSD is quick too, using its 4x PCI-E 3 bandwidth to hit read and write speeds of 2,070MB/sec and 920MB/sec respectively.

The high-end components, reliance on air cooling, close confines and numerous fans all contributed to a middling thermal performance though. The CPU's delta T of 67°C was calculated from a peak CPU temperature of 90°C at load, which is a little high, although within thermal limits, and the graphics card delta T peaked at a toasty 56°C as well.

Those warm figures are paired with a consistent deep rumble from the litany of fans. It doesn't vary, and it isn't irritatingly noisy, but the sound is certainly noticeable, especially when compared with a well-tuned quiet machine such as the near-silent Scan 3XS Z170 Vengeance Q (see Issue 151, p60).

Conclusion

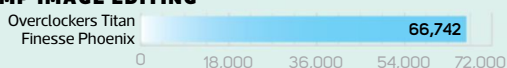
The Titan Finesse Phoenix offers 4K gaming abilities and solid application performance, along with a striking black and red design, for a very reasonable price. It isn't without issues. It gets hot, and it's a tad noisy compared with other machines in this league, but you can't argue with the performance you get for the money, and you get a well-balanced selection of components too. It's a rig that excels in several important areas rather than concentrating on one area to the detriment



of others. If you're looking for a fast, good-looking and well-built gaming rig that doesn't bump up the price with superfluous extras, the Phoenix is a great machine.

MIKE JENNINGS

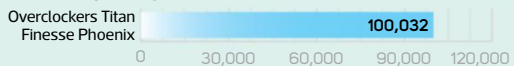
CPC REALBENCH 2015 GIMP IMAGE EDITING



HANDBRAKE H.264 VIDEO ENCODING



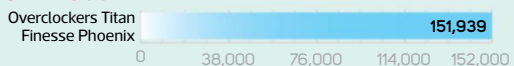
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 132.75%

SPEED
23/25

DESIGN
22/25

HARDWARE
23/25

VALUE
22/25

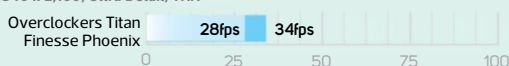
OVERALL SCORE
90%

FALLOUT 4

2,560 x 1,440, Ultra Detail, TAA



3,840 x 2,160, Ultra Detail, TAA

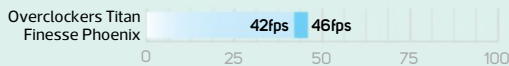


WITCHER 3

2,560 x 1,440, High Detail, AA on, HairWorks off

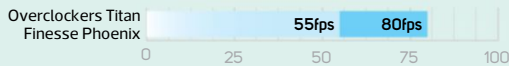


3,840 x 2,160, High Detail, AA on, HairWorks off

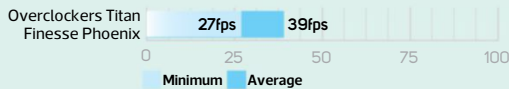


CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

VERDICT

Fast in every benchmark and with a striking design, this is a well-balanced and well-built gaming rig.

GAMING PC

Chillblast Fusion Brimstone / **£1,500** inc VATSUPPLIER www.chillblast.com

The Fusion Brimstone from Bournemouth-based Chillblast sports the type of graphics hardware we're not used to seeing inside a mid-range £1,500 gaming PC. Instead of the usual single-card setup, the Fusion Brimstone is packed with a pair of GTX 980 GPUs – and they're hefty, overclocked Windforce models made by Gigabyte. These triple-fan cards have had their 1126MHz base clocks boosted to 1203MHz, and between the two of them, they deploy 8GB of GDDR5 memory, 4,096 stream processors and more than ten million transistors.

Chillblast's concentration on graphics means that other components have been cut back though. The Core i5-6600K is Intel's best mid-range processor, and it's been overclocked from 3.5GHz to 4.4GHz, but has a smaller L3 cache and no Hyper-Threading. Meanwhile, the 16GB of memory is ample, but it only runs at 2133MHz – the slowest DDR4 frequency available.

The storage is middling too. The 250GB Samsung 850 Evo is a fine SATA drive, but the latest M.2 NVMe drives are significantly faster. None of these components is bad, but they're undeniably mid-range, and we'd say the same about the Gigabyte GA-Z170XP-SLI motherboard. It's designed for multi-GPU operation and runs its two primary PCI-E slots at 8x speed – so there's enough bandwidth to go around – but it's entirely conventional in most departments.

On the plus side, it has an M.2 connector, and its backplate has USB 3.1 Type-A and Type-C connectors alongside USB 3 ports and six audio jacks. It also has dedicated audio circuitry.

However, there are no on-board power and reset buttons, and the EFI menu system is clunky and unintuitive. In addition, many of its upgrade paths are hard to reach in this particular machine. Many of the free expansion slots can't realistically be accessed without removing a graphics card, and the same is true of the SATA ports. What's more, the M.2 port and one of the spare memory slots are both hidden by the Akasa Venom Voodoo CPU cooler – a heatsink that's so big it almost touches the case window.

All the kit is housed in an NZXT Source 340 case, which we recommend as a great budget case. The motherboard and components dominate the main area of the case, with the PSU and hard disk hidden behind a smart shroud that stretches across the entire bottom section, while cables are hidden behind a raised metal section.

On the outside, the case is glossy and dark, with subtle logos and no lights. It makes for a tidy system that emphasises components rather than cables, although there isn't any of the lighting or colourful cable sleeving that helps the Overclockers Titan Finesse Phoenix (see p60) to stand out.



Chillblast beats its rivals for warranty longevity though. The Brimstone is bolstered by a five year labour deal that also covers shipping and parts for the first two years.

Performance

The graphics cards are the undeniable stars of this system. All three of our test games never dropped below 30fps at 4K, which is fantastic for a £1,500 machine, and that's with Fallout 4 running in Ultra settings.

The emphasis on gaming performance means that the Chillblast is less impressive in application benchmarks, though. With its Core i5 CPU, it was consistently behind the Overclockers Titan Finesse in all our RealBench 2015 tests, except the LuxMark OpenCL test, thanks to the two GPUs. In particular, our heavily-multithreaded video encoding test suffers on the Chillblast. You'll only notice this performance difference if you regularly use multithreaded software though. The Core i5 chip still has four cores, and it's fast enough for most people's needs.

The SSD didn't break any records, either. Its read and write speeds of 493MB/sec and 470MB/sec respectively are fine for a SATA drive, but the Samsung SM951 inside the Phoenix rattled through those tests at 2,070MB/sec and 920MB/sec, thanks to its 4x PCI-E 3 bandwidth.

On the plus side, despite the cramped case and reliance on air cooling, the Brimstone did a decent job of cooling its components: the CPU and GPU delta Ts of 55°C and 57°C are warm, but not hot enough to ring any alarm bells. The noise output was similar.

The Brimstone was almost silent when running low-intensity tasks, but the fans quickly ramped up their speed during game tests. At peak load, the Chillblast was a little louder than the Overclockers machine – it's certainly audible, but the noise isn't irritating.

/SPECIFICATIONS

CPU 3.5GHz Intel Core i5-6600K overclocked to 4.4GHz

Motherboard Gigabyte GA-Z170XP-SLI

Memory 16GB 2133MHz Goldkey DDR4

Graphics 2 x Gigabyte GeForce GTX 980 4GB

Storage 250GB Samsung 850 Evo SSD; 1TB Seagate hybrid hard disk

Case NZXT Source 340

Cooling CPU: Akasa Venom Voodoo with 2 x 120mm fans; GPU: 6 x 80mm fans; rear: 1 x 120mm fan

PSU FSP Raider 750W

Ports Front: 2 x USB 3, 2 x audio; Rear: 3 x USB 3, 1 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 2 x USB 2, 1 x PS/2, Gigabit Ethernet, 6 x audio

Operating system Microsoft Windows 10 Home 64-bit

Warranty Two years parts and labour collect and return, followed by three years return to base labour only

- 1 The two GTX 980 cards are great for 4K gaming
- 2 The Akasa Venom Voodoo CPU cooler is a monster
- 3 The Source 340's shroud keeps the interior clutter-free



Conclusion

There's only so much that can be done with a £1,500 budget, and in this case, Chillblast has clearly chosen to pump most of its money towards the graphics department. That decision pays dividends in game benchmarks, where it's generally even faster than the Overclockers Titan Finesse. This machine has the pace to play any modern title at 4K, or on a VR headset, without any slowdown and that's a great achievement for a £1,500 machine.

However, this focus inevitably results in cutbacks elsewhere. The processor is mid-range, and the memory and SSD are both slower than you expect at this price. There isn't much room to upgrade this machine either, and there isn't any sign of attractive touches, such as lighting and colour-matched cables. These deficiencies are eclipsed by the Brimstone's sheer graphical power though. The Overclockers machine is much better balanced, but if 4K



gaming (or VR) frame rates are your priority, and you have a limited budget, the Fusion Brimstone delivers gaming performance in spades for a very reasonable price.

MIKE JENNINGS

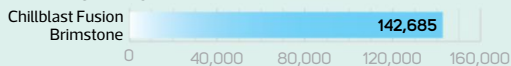
CPC REALBENCH 2015 GIMP IMAGE EDITING



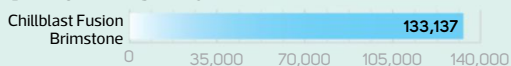
HANDBRAKE H.264 VIDEO ENCODING



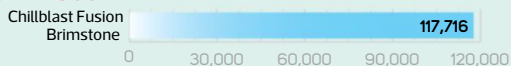
LUXMARK OPENCL



HEAVY MULTITASKING



SYSTEM SCORE



INTEL REFERENCE: 102.85%

SPEED
23/25

HARDWARE
20/25

DESIGN
20/25

VALUE
22/25

OVERALL SCORE

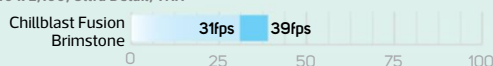
85%

FALLOUT 4

2,560 x 1,440, Ultra Detail, TAA

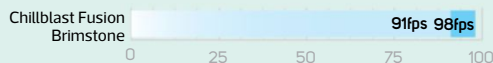


3,840 x 2,160, Ultra Detail, TAA

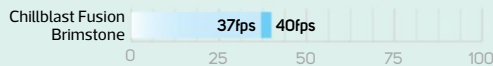


WITCHER 3

2,560 x 1,440, High Detail, AA on, HairWorks off

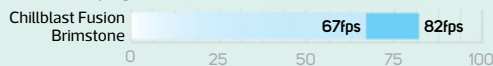


3,840 x 2,160, High Detail, AA on, HairWorks off

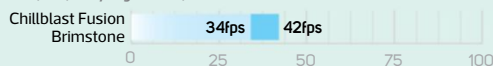


CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



3,840 x 2,160, Very High Detail, 0x AA



Minimum Average

VERDICT









Blistering speed in games and a tidy build, but the focus on GPU power sees the specification suffer elsewhere.

Elite

Our choice of the best hardware available

Build a home theatre PC

The parts you'll need to build an affordable, home theatre PC that's ideal for putting in the lounge and playing back all manner of video formats. This machine will handle general computing and media tasks with no trouble, and its dual-core Skylake CPU can even handle 4K video playback. Meanwhile, its super-quiet Noctua CPU cooler prevents it from making a racket.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Lian Li PC-Q09FNB with 300W FSP SFX PSU	www.overclockers.co.uk	Issue 149, p92	£110
	Intel Core i3-6100T	www.overclockers.co.uk	Issue 149, p92	£96
	Asus H110i-Plus D3	www.scan.co.uk	Issue 149, p92	£60
	8GB Corsair 2133MHz Vengeance LP DDR3 (CML8GX3M2A2133C11B)	www.scan.co.uk	Issue 149, p92	£46
	Noctua L9i	www.scan.co.uk	Issue 149, p93	£32
	Samsung SN-208FB	www.scan.co.uk	Issue 149, p93	£13
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Crucial 250GB BX100	www.ebuyer.com	Issue 144, p84	£63
	Logitech K400 Plus	www.dabs.com	Issue 149, p93	£31
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90
			TOTAL	£596

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ROG MAXIMUS VIII EXTREME / ASSEMBLY

**BREAK
THE RULES**

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Build a budget gaming PC

The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor, and even some games at 2,560 x 1,440. The machine has a discrete graphics card, a Skylake dual-core CPU and DDR4 memory. The ASRock Extreme4 motherboard is also capable of base clock overclocking via a BIOS update.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	ASRock Z170 Extreme4	www.scan.co.uk	Issue 151, p84	£111
	Intel Core i3-6100	www.scan.co.uk	Issue 151, p18	£95
	8GB (2 x 4GB) Corsair Vengeance LPX 2400MHz (CMK8GX4M2A2400C16)	www.scan.co.uk	Issue 151, p83	£41
	Asus Radeon R9 380 Strix 2GB	www.ebuyer.com	Issue 150, p48	£159
	250GB Crucial BX100	www.ebuyer.com	Issue 144, p84	£63
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£67
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90
			TOTAL	£767



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ROG MAXIMUS VIII FORMULA Z170 GAMING MOTHERBOARD

PERFECT YOUR BUILD
FROM **COOLING** TO **COLOUR**











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Build a mid-range PC



Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, a fast M.2 SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Asus Maximus VIII Ranger	www.scan.co.uk	Issue 147, p44	£145
	Intel Core i5-6600K	www.scan.co.uk	Issue 145, p17	£189
	8GB Corsair Vengeance LPX 2666MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£48
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£80
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£67
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	Samsung SSD 950 Pro 256GB	www.ebuyer.com	Issue 149, p48	£140
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90
			TOTAL	£922

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 Asus Radeon R9 380 Strix 2GB	www.ebuyer.com	Issue 150, p48	£159
	2,560 x 1,440 Asus Strix GTX 970	www.box.co.uk	Issue 150, p39	£285



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ROG MAXIMUS VIII GENE GAMING MOTHERBOARD

BEST GAMING PERFORMANCE

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











Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory, a high-speed M.2 SSD and an all-in-one liquid cooler.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£158
	Asus Maximus VIII Hero	www.overclockers.co.uk	Issue 146, p20	£177
	Intel Core i7-6700K	www.scan.co.uk	Issue 145, p17	£287
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£80
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£80
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£100
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Samsung SSD 950 Pro 512GB	www.ebuyer.com	Issue 149, p48	£245
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90
TOTAL				£1,272

Gaming PC

The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	2,560 x 1,440 Asus Strix GTX 970	www.ebuyer.com	Issue 150, p39	£285
	4K 2 x Nvidia GeForce GTX 970 4GB	www.ebuyer.com	Issue 140, p50	£570

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ROG MAXIMUS VIII HERO GAMING MOTHERBOARD

ACCEPT ALL CHALLENGES

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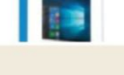
16 Media Awards
and counting



Build a high-end 6-core PC


Multi-threaded PC

The parts you'll need to build a PC with serious power in multi-threaded software, such as 3D rendering apps, video editing programs and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and top-end cooler listed. Also supplied is 16GB of RAM, a super-fast M.2 SSD, 1TB of extra solid state storage and Asus' superb X99 Deluxe motherboard.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Asus X99 Deluxe	www.overclockers.co.uk	Issue 136, p20	£320
	Intel Core i7-5820K	www.scan.co.uk	Issue 134, p43	£335
	Asus Radeon R9 380 Strix 2GB	www.ebuyer.com	Issue 150, p48	£159
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16)	www.scan.co.uk	Issue 136, p14	£95
	EKWB EK-Predator 240 Rev 1.1	www.scan.co.uk	Issue 148, p30	£168
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£100
	Samsung SSD 950 Pro 512GB	www.ebuyer.com	Issue 149, p48	£245
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£253
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90
			TOTAL	£1,892

4K gaming PC

This LGA2011-v3 system can support multiple graphics cards over 28 PCI-E 3 lanes, making it an ideal foundation for high-resolution PC gaming, replacing the graphics card listed above with two high-spec cards.










	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	4K 2 x Nvidia GeForce GTX 970 4GB	www.ebuyer.com	Issue 140, p50	£570
			TOTAL	£2,303



Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a short-PCB graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a high-speed M.2 SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i7-6700K	www.scan.co.uk	Issue 147, p84	£287
	16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz	www.scan.co.uk	Issue 147, p84	£80
	Corsair H80i GT	www.scan.co.uk	Issue 147, p84	£80
	Asus GeForce GTX 970 DirectCU Mini	www.cclonline.com	Issue 150, p38	£270
	Samsung SSD 950 Pro 512GB	www.ebuyer.com	Issue 149, p48	£245
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£10
	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£67
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£90

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£80
	Asus Z170i Pro Gaming	www.eclipsecomputers.com	Issue 147, p26	£124
			TOTAL	£1,388

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£70
	Asus Maximus VIII Gene	www.eclipsecomputers.com	Issue 147, p42	£168
			TOTAL	£1,422

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NVIDIA











STRIX-GTX970-DC20C-4GD5 GAMING GRAPHICS

Unleash your
gaming instincts




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Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Budget ATX	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	Sub-£100 ATX quiet	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£80
	Sub-£100 ATX performance	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Sub-£150 full-sized ATX quiet	Nanoxia Deep Silence 5	www.quietpc.com	Issue 144, p50	£115
	Sub-£150 full-sized ATX	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Sub-£150 mid-size ATX	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£158
	Mini-ITX tower	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£80
	Mini-ITX cube	Fractal Core 500	www.scan.co.uk	Issue 150, p20	£50
	Micro-ATX	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£70
	Water-cooling micro-ATX	Parvum Systems S2.0	www.overclockers.co.uk	Issue 129, p22	£140

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	1,920 x 1,080 gaming	Asus Radeon R9 380 Strix 2GB	www.ebuyer.com	Issue 150, p48	£159
	2,560 x 1,440 gaming	Asus Strix GTX 970	www.ebuyer.com	Issue 150, p39	£285
	High-end single-GPU gaming	EVGA GeForce GTX 980 Ti Classified ACX 2.0+	www.scan.co.uk	Issue 147, p24	£594
	4K gaming	2 x Nvidia GeForce GTX 970 4GB	www.ebuyer.com	Issue 140, p49	£570
	Mini-ITX	Asus GeForce GTX 970 DirectCU Mini	www.cclonline.com	Issue 150, p38	£270

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STRIX GTX 980 TI-DC30C-6GD5 GAMING GRAPHICS

**30% COOLER.
ODB GAMING.**



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Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Mid-range 550W	EVGA SuperNova GS 550W	www.dabs.com	Issue 146, p50	£67
	High-end 550W	Super Flower Leadex Platinum 550W	www.overclockers.co.uk	Issue 146, p52	£88
	Mid-range 750W	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£100
	High-end 1.2kW	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£275

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Router	Asus RT-AC68U	www.cclonline.com	Issue 128, p88	£150
	Wi-Fi adaptor	Asus PCE-AC68	www.dabs.com	Issue 128, p88	£70

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Hard disk	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
	250GB SATA SSD	Crucial BX100 250GB	www.scan.co.uk	Issue 141, p43	£63
	1TB SATA SSD	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£252
	High-performance M.2 SSD	Samsung SSD 950 Pro 512GB	www.ebuyer.com	Issue 149, p48	£245
	NAS box	Synology DS215J	www.cclonline.com	Issue 138, p17	£133

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STRIX-R9380X-OC4G GAMING GRAPHICS

ASUS STRIX R9 380X delivers pumped gaming performance and extreme reliability.


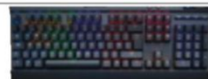






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Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	24in monitor	Dell U2414H	www.overclockers.co.uk	Issue 129, p43	£189
	27in 4K monitor	Asus PB279Q	www.overclockers.co.uk	Issue 151, p40	£560
	27in G-Sync monitor	Asus ROG Swift PG278Q	www.scan.co.uk	Issue 143, p44	£520
	27in FreeSync monitor	BenQ XL2730Z	www.overclockers.co.uk	Issue 143, p46	£456
	27in 4K G-Sync monitor	Asus ROG Swift PG27AQ	www.scan.co.uk	Issue 151, p42	£716
	27in 5K monitor	Dell UltraSharp UP2715K	www.scan.co.uk	Issue 151, p44	£938

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Mechanical gaming keyboard	Cooler Master MasterKeys Pro S (Pro L version recommended if you need a numeric keypad) UPDATED	TBC	Issue 152, p44	£109
	Premium mechanical gaming keyboard	Corsair K70 RGB UPDATED	www.amazon.co.uk	Issue 152, p41	£155
	Budget gaming mouse	Cooler Master XorNet II	www.cclonline.com	Issue 149, p28	£21
	Gaming mouse	Logitech G402 Hyperion Fury	www.scan.co.uk	Issue 139, p53	£40
	Ambidextrous gaming mouse	Roccat Kova	www.cclonline.com	Issue 150, p28	£50
	MMO gaming mouse	Corsair Scimitar RGB	www.scan.co.uk	Issue 150, p17	£71
	Wireless gaming mouse	SteelSeries Sensei Wireless	www.overclockers.co.uk	Issue 139, p61	£100
	Flight stick	Saitek X-55 Rhino H.O.T.A.S.	www.overclockers.co.uk	Issue 131, p29	£170

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Z170I PRO GAMING MINI-ITX MOTHERBOARD

**MINI SIZE.
MAXIMUM WINS.**









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Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	PCI-E sound card	Asus Strix Raid DLX	www.scan.co.uk	Issue 148, p28	£150
	2.1 speakers	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£140
	Soundbar	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£165
	Headset	HyperX Cloud II	www.scan.co.uk	Issue 142, p46	£70
	Surround-sound headset	Asus Strix 7.1	www.dabs.com	Issue 142, p43	£132

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Quiet gaming PC	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 151, p60	c.£1,500
	Dream PC	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	Sub-£2,000 gaming PC	CyberPower Infinity X77 Deluxe	www.cyberpower system.co.uk	Issue 150, p56	£1,999
	Skylake PC	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 145, p66	c. £1,449
	Mini-ITX gaming PC	Chillblast Fusion Fury Nano	www.chillblast.co.uk	Issue 147, p56	c.£1,619
	Premium PC	Scan 3XS X99 Carbon Extreme SLI	www.scan.co.uk	Issue 148, p62	c.£4,799
	Water-cooled PC	Overclockers Infin8 Toxicity	www.overclockers.co.uk	Issue 150, p58	c.£3,414
	Gaming laptop	CyberPower Fangbook 4 SK-X17 UPDATED	www.cyberpowersystem.co.uk	Issue 152, p30	£1,909

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Z170 PRO GAMING MOTHERBOARD

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Games



Featured this month

Inverse look p75 / XCOM 2 p76 / Rise of the Tomb Raider p78 / Darkest Dungeon p78 /
Firewatch p80 / The engine room – Foundation p82 / Indie corner p84



RICK LANE / INVERSE LOOK

MEMORY CORRUPTION

Gaming history will slip through the cracks unless we act to preserve it, argues Rick Lane

We've reached a critical point in the evolution of games. Despite still being considered a new art form, video games haven't been a new idea for a long time. Gaming has been popular entertainment for over 40 years, in fact, with the earliest examples going as far back as the 1950s.

In other words, gaming is a timeline with which we can clearly trace its evolution. At the same time, we're very fortunate that the vast majority of this history still exists within living memory. Most of its important figures – Nolan Bushnell, Clive Sinclair, Shigeru Miyamoto – are still very much alive. If we want to know what gaming was like in its early days, we can still ask someone who was there at the time. But this window of opportunity dwindles every day, and not only is the industry failing to make the most of it, but in some ways, it's actively obstructing our ability to acquire and share knowledge about the medium's past.

Part of the problem is this enduring misconception that gaming is a new medium. We like to focus on the new aspects of gaming – the cutting edge, the latest graphics card, the next big game. Gaming is constantly refreshing itself, so we generally don't assign much value to older games and consoles. Meanwhile, the games themselves are perceived as highly durable creations. At the end of the day, they're just lines of code, immune to decay, endlessly copyable and almost impossible to destroy.

But nothing lasts forever, and games are no exception. While the software itself might not change, the environment in which it exists evolves constantly. Changes in hardware and gaming platforms can lead to compatibility problems, while upgraded hardware can make older games less playable (such as playing a low-resolution game on a high-resolution screen). It's also

reasonable to argue that preserving the original gaming experience is as important as preserving the game itself. Playing Asteroids on your current PC, for example, is nowhere near as entertaining as playing it on its original arcade machine with its chunky controls and dazzling vector display.

But only a handful of individuals possess the knowledge to repair and maintain those classic arcade machines, and unless this information is passed on, that number will only decrease until a day comes when those machines are no longer usable.

Where the industry really struggles when it comes to preserving its history, however, is in passing on knowledge about the creation of games. In this respect, the industry isn't just ignorant, but downright resistant.

To protect their interests during a game's development, many companies require their employees to sign non-disclosure agreements (NDAs), which prevent developers from talking

about the project without permission, with the implied threat of legal action. But many such documents don't specify an end date to this legal gagging order, leaving developers uncertain about what they can discuss about a game for years, even decades after the game's release.

Consequently, we may never hear the inside story of a particular game's development, or see projects that studios started but never put into full production. All of which makes it harder for the industry to learn from its own successes and failures, as well as presenting us with an incomplete picture of gaming history.

There's still time to address this issue, and start paying more attention to preserving the legacy of gaming. If we don't, some of these untold stories will be lost forever. **OP**

Many such documents don't specify an end date to this legal gagging order

Rick Lane is Custom PC's games editor. [@Rick_Lane](#)



XCOM 2 / £35 inc VAT

DEVELOPER Firaxis / PUBLISHER 2K Games / WEBSITE www.xcom.com



Providing more evidence that the XCOM series is about coping with failure, XCOM 2 begins with players having lost the war for Earth in the 2012 reboot, *Enemy Unknown*. Set 20 years after the events of Firaxis' fearsomely challenging strategy game, XCOM 2 shows us an Earth under the tentacle of the aliens – a neo-fascist dystopia where humans are treated like cattle and have been brainwashed into thinking the ranch is for their benefit. The handful of individuals able to resist the aliens' domination are scattered and divided, and all that remains of XCOM itself is a vague memory of hope.

That's enough, however, to see the XCOM program reignited. XCOM 2 puts you back in the Commander's Chair, with a swanky new mobile Headquarters and a much wider array of tactical options at your disposal. You're going to need them, because the enemy is more powerful, more

uncompromising and more inscrutable than before.

XCOM 2 sees a significant reworking of the game's structure on both a tactical and strategic level. Initially, you're essentially a guerrilla movement rather than an international SWAT team, so instead of trying to juggle different countries' needs through an extensive but fragile satellite network, you're simply trying to connect the various resistance movements across the globe. These nodes of sanctuary provide XCOM with vital Supplies and Intel, the game's two key resources, in exchange for occasional support against raids by ADVENT – the aliens' genetically modified police force.

XCOM 2's mantra is very much 'the best defence is a good offence' – it constantly pushes you into moving against the enemy. ADVENT doesn't sit idly waiting for

you to build up your forces. It counters your technological advancement through Dark Events, gradually increasing its power throughout the game. At the same time, the aliens are working on a larger project that, if completed, will instantly result in the destruction of XCOM and the end of the game. Stopping the aliens from overwhelming your neophyte resistance requires frequent and direct intervention, destroying research facilities and completing specific missions to counter one of several Dark Events.

As with *Enemy Unknown*, you can't do everything, and part of the game's strategic thrill comes from balancing the need to attack with the need to gather supplies and research new technologies. Supply drops, guerrilla ops and various other opportunities appear regularly across the globe, each offering vital resources such as new engineers or scientists.

However, all these goodies take several in-game days to acquire; time that could give ADVENT the opportunity to push its XCOM-destroying project one step closer to completion.

The base-building aspect of XCOM 2 has also been changed. Engineers can now be staffed in specific construction projects to speed them up, but also to other jobs such as increasing your generators' power output, or increasing the efficiency of weapons development. A major new feature is the Proving Grounds, where experimental weapons are researched and the output is random. Researching a new heavy weapon might provide a flamethrower, while experimenting with new ammo might create poisonous rounds that do damage over time. Standard research also yields new items, such as the fantastic Mimic, which generates a decoy unit that attracts

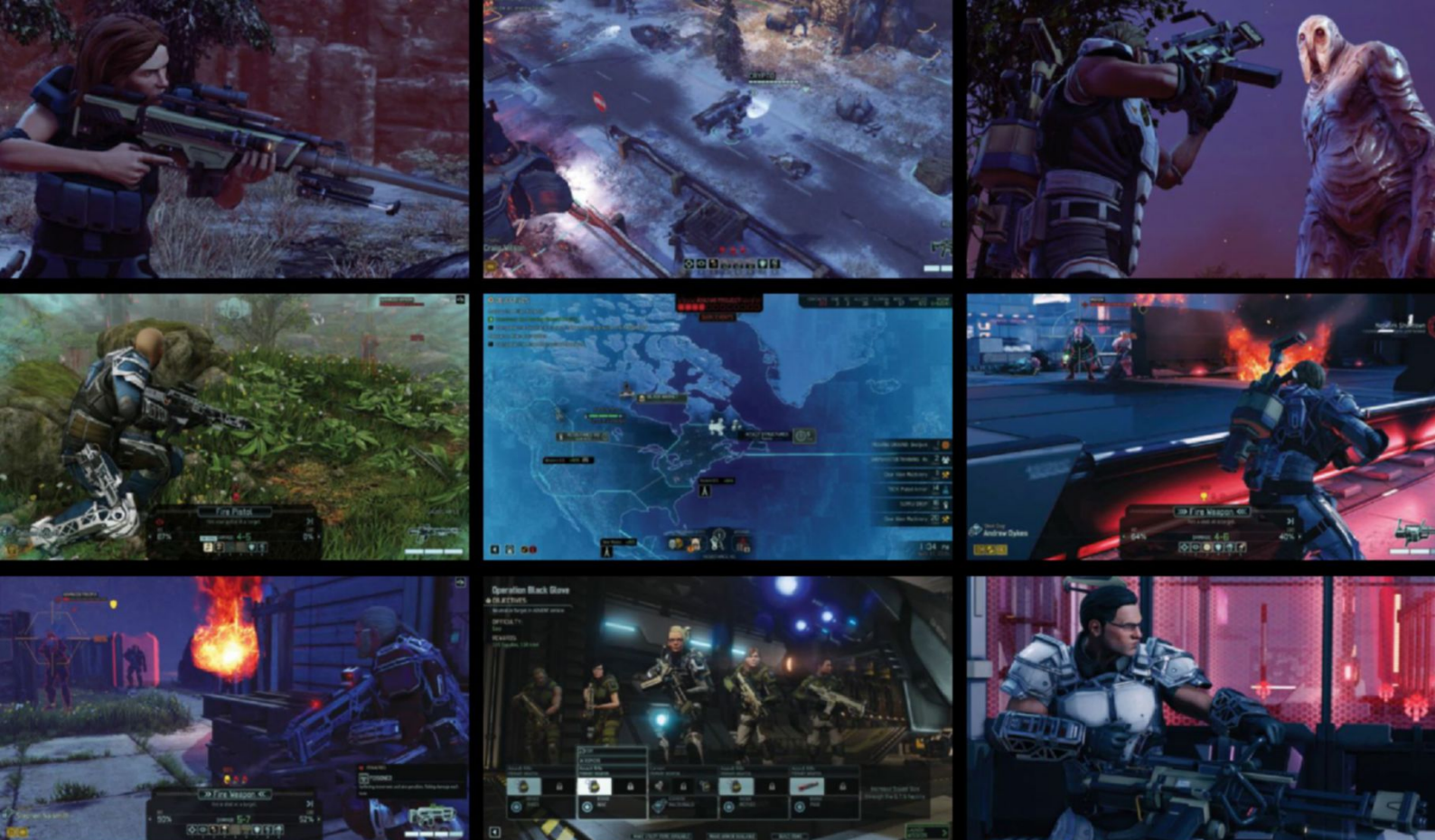
*If you don't act fast
you will eventually
be overwhelmed*

OVERALL SCORE

90%

/ VERDICT

Cerebral, action-packed and harder than a Titanium bear, we welcome the new alien overlord of strategy games.

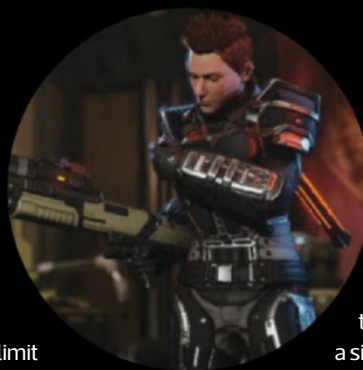


alien fire for a single, yet often tactically vital turn.

The alterations to the ground combat are less extensive, but still result in a game that feels very different. Your new position as a resistance movement means that many missions are now time sensitive, giving you a strict turn limit. As with the larger changes to the game, this limit necessitates a more aggressive strategy, pushing forward against the enemy rather than sitting back and taking pot shots through Overwatch – wherein your soldiers shoot at the first enemy that moves within range. Moreover, the aliens also have the ability to summon reinforcements every few turns, so if you don't act fast, you *will* eventually be overwhelmed.

To keep up with this faster moving, yet tactically broader game, both sides are allowed more immediate access to powerful abilities. Sectoids, an early alien unit, can use mind control immediately, while your soldier classes gain powerful secondary weapons at Squaddie rank, such as the Ranger's sword for devastating close-combat attacks, or the Support Unit's Gremlin Drone, which can hack mechanised units or provide remote healing to squadmates instantly. The increased power of both sides is represented visually by a more destructive environment. Entire buildings can be slowly ripped apart over the course of a mission, which has additional tactical ramifications in terms of the cover available, and the damage environmental objects can cause to units.

As such, there's no 'right' approach to any XCOM mission – it all depends on the soldiers and equipment you take with you, and how you use them to adapt to the challenges thrown your way. The game's emotional impact is also



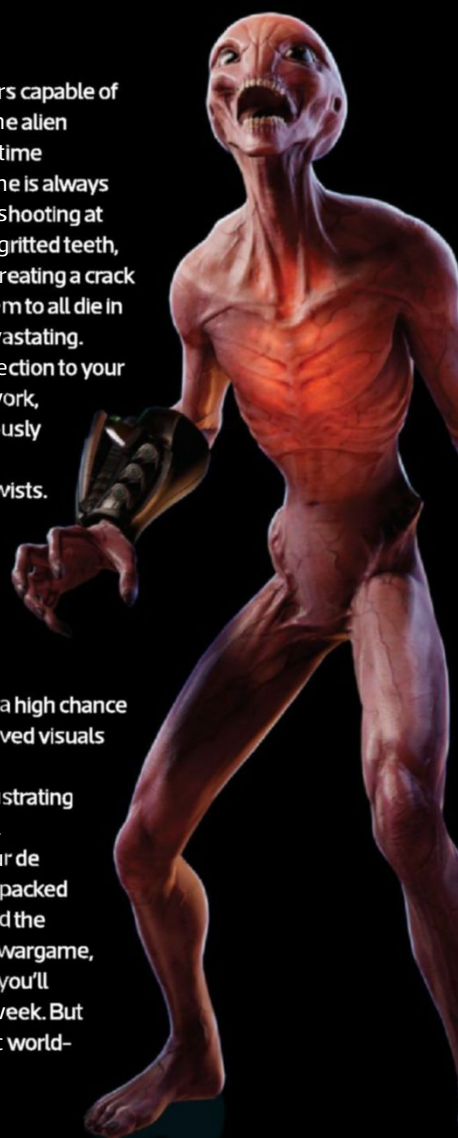
significant. Creating soldiers **capable** of standing toe to toe with the alien menace requires a huge time investment, and losing one is **always** heartbreaking – an alien shooting at your soldiers is cause for **gritted teeth**, and if you've spent hours creating a **crack** team of soldiers, only for them to **all die** in a single mission, it's simply devastating.

The game compounds this connection to your team through fantastic animation and voicework, alongside a central story that threads ingeniously through the game's emergent systems, with carefully measured plot beats and gripping twists. XCOM 2 has more than just a clever brain; it has a heart and soul too.

A few of the tactical changes are a little galling though. Many enemies can now 'dodge' attacks and you can't account for these events, so it really grates when you've carefully positioned your squad to give them a **high chance** of hitting their target. What's more, the improved **visuals** and greater tactical breadth come at a cost of performance, with lengthy load times and **frustrating** pauses between friendly and enemy actions.

Otherwise, though, XCOM 2 is a tactical tour **de force**, providing the thrills of the most action-packed FPS, the narrative drama of an HBO series and the strategic depth of the most carefully layered **wargame**, all in a single package. You'll laugh, you'll cry, you'll slam the desk and swear off the game for a **week**. But we guarantee you'll return to Fraxis' majestic **world-saving** puzzle.

RICK LANE





Rise of the Tomb Raider / £40 inc VAT

DEVELOPER Crystal Dynamics / PUBLISHER Square Enix / WEBSITE www.tombraider.com



Rise of the Tomb Raider is the sequel to the 2013 Tomb Raider reboot, which sees Lara Croft embarking on her first proper expedition after the events that transformed her into the mass-murdering, animal-slaughtering, relic-nicking icon of the 1990s. It offers more of the frenetic action sequences and liquid-smooth platforming we enjoyed in the reboot two years ago, but it's bogged down in a story that fails to build on the groundwork laid in 2013.

OVERALL SCORE

70%

/ VERDICT

Visually stunning and packed with thrilling action, Rise of the Tomb Raider is let down by a dull yet insistent narrative.

This time, the meat of the action is set in Siberia, as Lara attempts to find the lost city of Kitezh, which contains the fabled power of the Divine Source. After a garbled introduction that sees Lara briefly skip between London and Syria, the game finally settles into exploring Russia's most inhospitable province and opens up properly.

A unique blend of semi-open world platforming, third-person shooting and tightly scripted action sequences then commences, in which Lara is pummelled by the scenery exploding around her. Rise of the Tomb Raider is an incredible spectacle. Siberia is a mountainous deathtrap of blood-freezing blizzards, precarious ice walls and thundering avalanches. The



scenery creaks, cracks and shatters as Lara leaps around a world built from dizzyingly high rock faces, rusting Soviet military bases and the ruins of ancient civilisations. In terms of visuals and animation, Crystal Dynamics' sterling work is the best you're likely to see right now.

These sections are less frequent than in the previous game, however, being spaced out between greater exploration opportunities and more creative gunfights. The combat is particularly improved, giving Lara more freedom to adopt a stealthy approach using melee attacks and her bow, while adding a neat mechanic whereby she can pick

Darkest Dungeon / £15 inc VAT

DEVELOPER Red Hook Studios / PUBLISHER Red Hook Studios / WEBSITE www.darkestdungeon.com



Darkest Dungeon is probably the most misanthropic game we've ever played. It doesn't like itself. It doesn't like the characters it tears apart both physically and psychologically, and it likes the player least of all. It's a game you admire rather than enjoy.

Make no mistake, Darkest Dungeon is well made. It starts with the player inheriting a wealthy mansion estate from a long-lost family member. Unfortunately, your inheritance is a poisoned chalice – the estate is cursed and the mansion filled with all manner of nasty creatures. To claim your inheritance, you must first rid the estate of its denizens by

hiring parties of heroes and guiding them through randomly generated dungeon maps, clearing them of monsters.

It's a standard rogue-like structure with one major twist – heroes aren't merely at risk of physical damage from their adventures, but mental damage as well. If a hero undergoes too much 'stress', they suffer an affliction such as Selfish, Irrational or Masochistic, which affects their behaviour during combat. These afflictions can ripple through your party, and what might begin as a potentially lucrative quest ends up unravelling quicker than a ball of wool at a cattery.

OVERALL SCORE

60%

/ VERDICT

Although stylish and inventive, Darkest Dungeon is simply too gruelling for its own good.





up junk from the environment and craft ad-hoc weapons such as grenades and Molotov cocktails. There's also a heavier emphasis on plundering tombs and solving puzzles, both in the central story and the optional 'Challenge Tombs' that litter the map. These environmental conundrums are undoubtedly the highlights of the game, being imaginative, enjoyable to unpick and perfectly judged in difficulty.

Unfortunately, this more open game structure still comes second to a linear story that sadly, isn't all that interesting. It's a fairly straightforward relic hunt in the vein of Indiana Jones, but lacking any of the wit. Lara is a likeable enough

heroine, but the supporting cast members are one-dimensional and flatly written. The pace of the game is also constantly broken up by relentless audio logs, which are little more than tedious lore expositions that you have to stand still to listen to.

As a game about jumping through spectacular locations and shooting bad men in the face, *Rise of the Tomb Raider* is thoroughly entertaining. Unlike the previous game, however, the story feels like it's hindering the action rather than facilitating it.

RICK LANE

It's a brilliant idea, and just one of a whole host of systems that can affect the outcome of an expedition. *Darkest Dungeon* sports a huge range of characters to recruit and monsters to fight, each with unique abilities. Before you embark upon a quest, you must anticipate the obstacles you'll face and equip supplies accordingly. Come across a tunnel blockage without a shovel, for example, and your party will suffer stress and damage tearing it down by hand. Even the light level of your torch can be the difference between life or death, affecting the chance of being ambushed and the toughness of your opponents.

This intricate web of systems can produce wonderful little stories. When a character's resolve is tested, for example, they may gain a Virtue rather than an Affliction, making them stronger. More often than not, though, the outcome leans toward the negative side of the scale –

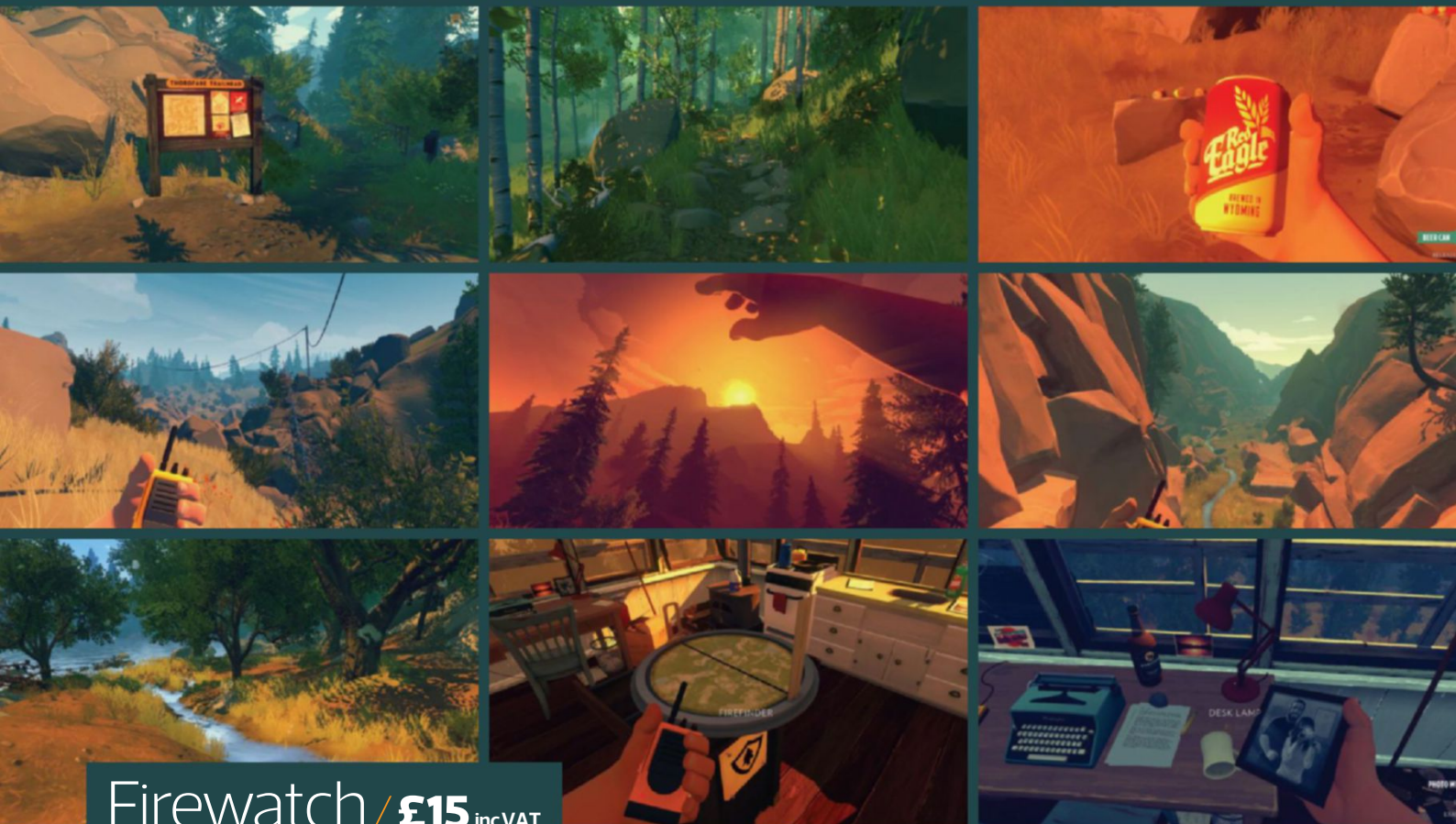
Darkest Dungeon is an incredibly tough game that punishes mistakes with extreme severity.

That isn't necessarily a problem, but *Darkest Dungeon*'s fearsome challenge is paired with a lengthy metagame, which requires you to painstakingly upgrade several buildings that provide essential services to your heroes. If you suffer a particularly bad failure, it can take hours to recover, in which you recruit new heroes and slowly build their Resolve.

Not only does this setup make you feel like you're being punished for having the audacity to play the game, but there isn't enough meat on the core systems to justify the time investment required to progress. What begins as a gripping, shocking dark fantasy eventually transforms into a miserable slog.

RICK LANE





Firewatch / £15 inc VAT

DEVELOPER Campo Santo / PUBLISHER Campo Santo / WEBSITE www.firewatchgame.com

Ostensibly about loneliness, isolation and respite, Campo Santo's gorgeous hiking simulator *Firewatch* casts you as Henry, a newly enlisted lookout in a Wyoming fire tower that's situated miles from civilisation. Henry has taken the job to escape his current life and find some inner peace. It's a game of two halves, either of which would have worked superbly in the setting, but sometimes rub together uncomfortably.

The first half is an effortlessly charming game about exploring and navigating an incredibly pretty open world where summer seems to radiate from the very earth. Campo Santo's environment design provides a powerful sense of the great outdoors in a landscape that's

nevertheless very tidy and compact, enabling you to experience all the game can offer in around five hours.

The paths and obstacles that pepper the Shoshone Forest are mazy enough to be gently challenging, enabling you to divide your focus between the game world and your radio conversations with Delilah, who starts off the game as Henry's mentor, but evolves into a friend and possibly more. You can respond to Delilah's messages in various ways through a silky-smooth dialogue system that provides a wonderfully tactile sense of chatting over radio. With a script penned by *The Walking Dead*'s Sean Vanaman, and A-list acting talent including *Mad Men*'s Rich Sommer (Harry Crane), *Firewatch*'s characterisation is first-rate.

For a few hours, *Firewatch* flits between lackadaisical comedy as city boy Henry bumbles

around the forest, tumbling down scree slopes and awkwardly trying to deal with mischievous teenage girls, and a slightly more serious bent as both characters discuss the sad circumstances that led them to choose such a lonely lifestyle. Then, halfway through, *Firewatch* becomes more akin to a thriller. The once-peaceful forest becomes fraught with paranoia, while Henry and Delilah's relationship is tainted by fear and mutual suspicion.

As a thriller, *Firewatch* is just as effective, powerfully conveying a sense of being constantly watched. However, the transition happens too suddenly, with *Firewatch* skipping through the middle of the story in what's effectively a montage.

This compression of time damages what's supposed to feel like a long, hot summer. As soon as we become acquainted with these fantastic characters, *Firewatch* suddenly begins racing to a conclusion.

It's a strange problem, but *Firewatch* does such a good job of making the mundane life of a fire lookout interesting that its sudden narrative thrill seeking is weirdly disappointing. The second half has a decent story, with an entertaining plot and an atmosphere that manages to feel oppressive and frightening in broad daylight, but we're unsure if *Firewatch* needed to switch so dramatically. Nevertheless, in both the quality of its writing and its experimentation with small-scale open-world design, *Firewatch* marks an important step forward for first-person adventure games.

RICK LANE

OVERALL SCORE

84%

/ VERDICT

A splendidly written and designed exploration game, although its desire to both thrill and chill results in uneven storytelling.

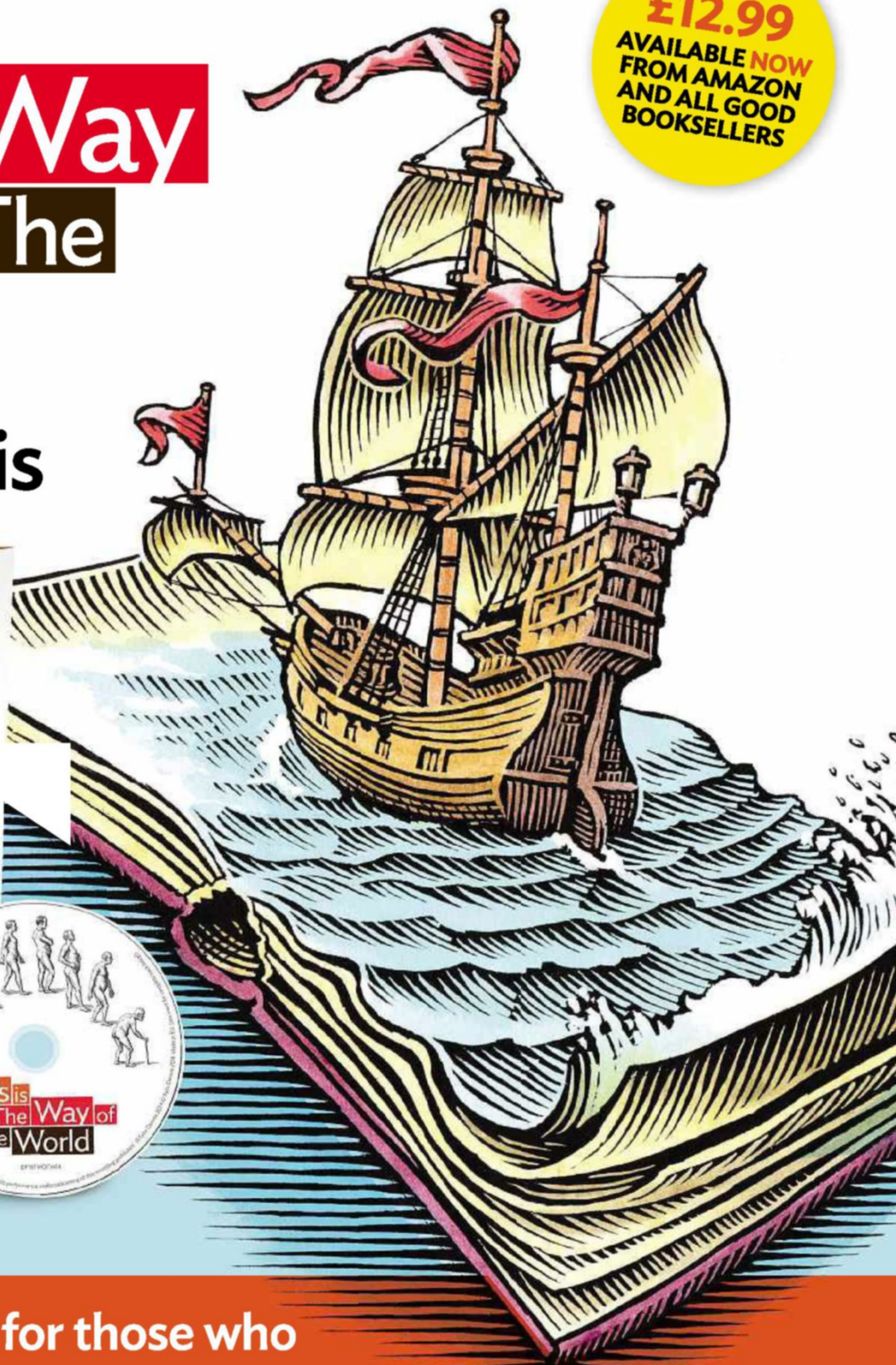
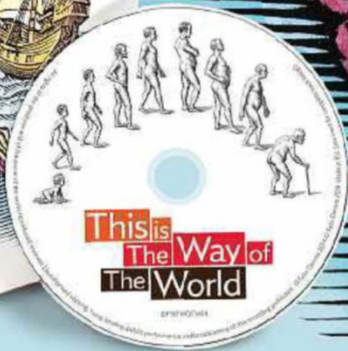
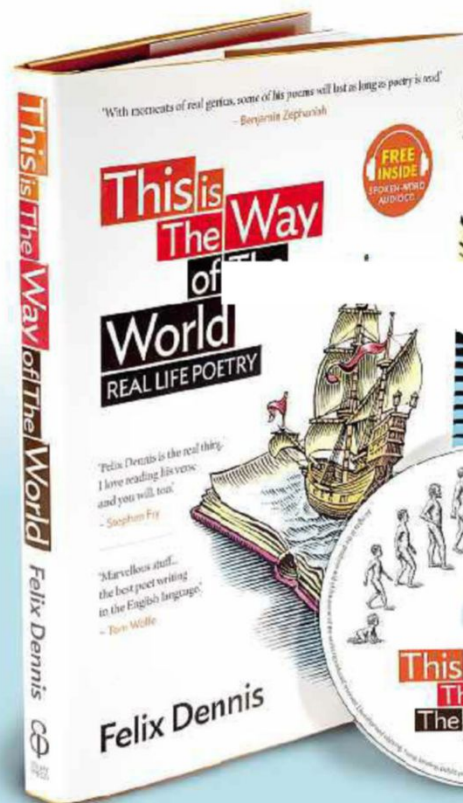
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RICK LANE / THE ENGINE ROOM

Foundation

Rick Lane speaks to Crystal Dynamics about its work on the Tomb Raider reboot and its graphically groundbreaking sequel

The Tomb Raider series has always been a technological pioneer, ever since Core Design wowed players with its 3D environments back in 1996. Since then, the series has been rebooted twice (three times if you include the disastrous *Angel of Darkness*). The later, successful reboots were handled by Crystal Dynamics. Both were designed around a new generation of console hardware, and both upheld the series' tradition of pushing the boundaries of games' visual capabilities.

For the series' latest incarnation, which kicked off with 2013's darker, grittier *Tomb Raider*, and was followed this year by *Rise of the Tomb Raider* (see p78), Crystal Dynamics wanted to create a more realistic Lara Croft in a game that combined the hallmark environmental platforming with dazzling set pieces. This aim meant creating an engine to match. 'We took all our engineers and put them against a dozen or so major



Lara's movements and facial expressions are all motion-captured. Lara's face is based on Megan Farquhar, while the performance is provided by Camilla Luddington

renovation projects to increase the flexibility of the code and the productivity of our content developer,' says Gary Snethen, chief technical officer of Crystal Dynamics.

The roots of the Foundation engine's codebase go as far back as Crystal Dynamics' early work, such as *Legacy of Kain: Soul Reaver*, so much of the initial focus was on updating the tech for the new *Tomb Raider* project. 'Many engineering teams make the mistake of building great technology for technology's sake,' says Snethen. 'We focused instead on the singular goal of making great games, and approached the engine work as building a great foundation upon which we could build a great game. When we finished the work and were happy with the results, it seemed natural to name our new engine Foundation.'

The focal point of this design was Lara herself. One of gaming's most iconic characters, Crystal Dynamics wanted to update Lara for a modern audience, to make her more human

and relatable, and less of an Indiana Jones caricature. At the same time, the team wanted to create a platformer with much greater nuance than seen previously. In both cases, detailed animation was vital for achieving the right results.

'We use a variety of techniques,' says Snethen. 'For basic full body animations, our animators use motion capture suits to capture rough animations themselves, and then refine these animations by hand. For high-fidelity animation, we capture both the body and facial performance of professional actors in a motion capture studio and then refine them by hand.' For both the 2013 reboot and *Rise of the Tomb Raider*, Lara's face was based on that of model Megan Farquhar, while actress Camilla Luddington provided the character's voice and motion-capture performance.

Meanwhile, the platforming in the most recent *Tomb Raider* games has a much greater emphasis on spectacle than that of earlier titles, with Lara often leaping and scrambling along buildings and terrain that crumble and collapse around her. This destruction is



Rise of the Tomb Raider includes deep snowdrifts that deform procedurally as Lara trudges through them



Many of *Tomb Raider*'s action sequences seamlessly blend baked animations into real-time scenes

largely driven by the game's proprietary physics engine, but Crystal Dynamics has an interesting approach to some of the more bombastic sequences. 'We create some of our large-scale destruction effects with offline tools and then bake them into animations and movies, which are then composited into the scene in real time as the game is played,' says Snethen.

The game is also set in Siberia, so the developers wanted to hammer home the hostile nature of this icy wilderness, building multiple visual effects around the simulation of snow and ice.

'Our deep deformable snow grounds Lara in the environment and allows the player to feel her struggle for survival as she occasionally trudges through deep and drifting snow, while hunting, gathering wood, building campfires and so on,' Snethen explains. 'Our snow and ice graphics shaders allow the player to see glints of individual ice crystals on the ground and refracting colour through deep translucent ice. And, of course, Lara has a full suite of context-aware animations, so she can react to the extreme environments in which she finds herself.'

This newer version of Foundation also includes more general upgrades. TressFX, the AMD technology for physically simulating Lara's hair, has been replaced with a system called Purehair, co-created by Crystal Dynamics and an R&D team named Labs. 'We changed the way hair is authored, rendered and simulated,' says Snethen. The result has a similar overall effect to TressFX, but has a much smaller impact on



performance and doesn't play favourites between Nvidia and AMD GPU hardware.

Foundation also features Crystal Dynamics' own screen space ambient occlusion (SSAO) system, called Broad Temporal Ambient Obscurance, or BTAO. 'The goal of all SSAO systems is to darken concave edges and corners in the 3D scene. This lighting effect occurs in the real world because corners, cracks and crevices receive light in the environment from fewer directions than a more exposed surface,' Snethen explains. 'One of the major differences between BTAO and the other techniques is that BTAO uses information from previous frames, in order to reduce the calculations needed in subsequent frames.'

Away from visual changes, two further alterations to Foundation have a significant effect on the player's experience. The first concerns Tomb Raider's combat system, particularly the enemy AI, which has been changed from a fairly rudimentary FPS-like AI to a hierarchy that resembles games such as Dishonored or Far Cry. 'Our enemies now have the ability to catch a glimpse of Lara, without recognising her, which can prompt

Foundation includes pixel shaders designed specifically to simulate icy surfaces

them to walk over and investigate,' says Snethen. 'Enemy senses are now attenuated by concealment or camouflage until they're very close to Lara. When they're surprised by a noise or someone being hurt, enemies will begin a search for the source, but they won't know Lara's location until they spot her.'

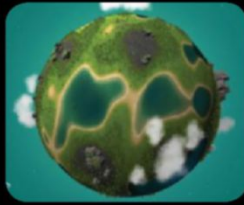
The other major change concerns Foundation's level-sculpting toolkit. 'Before Rise of the Tomb Raider, all objects were placed in the game world in the same way props are placed on a stage,' Snethen explains. 'Now, objects can be used as ingredients of other objects, and entire levels can be constructed from hierarchies of objects. These compound objects can also be inherited, branched and procedurally modified so they can be used as reconfigurable templates.' This system is showcased by Rise of the Tomb Raider's Endurance Mode, an alternative game mode that focuses on emergent survival situations in procedurally generated landscapes. Crystal Dynamics also states that this system will have a major impact on its games for many years to come, so we can expect to see other games from the studio with a more procedural focus. **GPU**



Many of Tomb Raider's platforms are physically active, and will break and shatter under Lara's weight

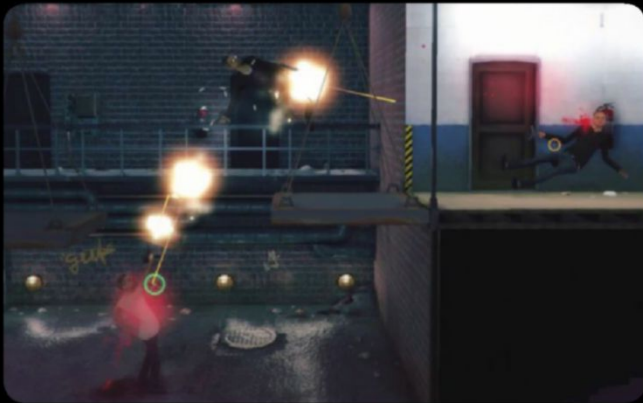


Rise of the Tomb Raider's AI has more behaviour-states, letting the player adopt a stealthy approach with greater success



INDIECORNER

In space, no one can hear Rick Lane round up the latest and greatest indie games. Unfortunately, we're not in space, so you're stuck with him. Sorry



My Friend Pedro: Blood Bullets Bananas

DEVELOPER Deadtoast.com / RELEASE TBA

Normally, we wouldn't advocate such heresy, but on this one occasion, we'd like you to, very briefly, put down this magazine. Then head immediately to that non-paper-based abomination that is the Internet, get on YouTube and watch the trailer for My Friend Pedro. When you've seen it in motion, you'll be able to fully appreciate why we're so excited about this bizarrely named, side-scrolling action game that's heavily inspired by Max Payne. Originally a free 2D game on Kongregate, this new version has been rendered in full 3D and, more importantly, incorporates its physics engine into every aspect of its design.

The latter allows you to pull off incredible acrobatics, somersaulting onto platforms, drop-kicking enemies out of windows and even backflipping off enemies before shooting them full of lead. At the same time, the player can interact with objects in the game world. You can kick a metal object into the air, then use it to ricochet bullets around blind corners, or kick an enemy's decapitated head into another opponent's head, knocking them cold.

Even at this relatively early stage, the gameplay looks completely and utterly ridiculous, and the developers are adding new features with almost frightening speed. There's no release date yet, but you should definitely keep My Friend Pedro on your radar.



The Universim

DEVELOPER Crytivo Games / RELEASE TBA

Games don't come much more ambitious than The Universim. Resembling the offspring of Civilization and Spore, The Universim is a god game that lends you control of the entirety of creation. It procedurally generates planets, no two of which are alike, and you then guide that planet's life (assuming it has any) from its pre-animal form to a hyper-intelligent, intergalactic civilisation.

These civilisations comprise semi-autonomous creatures that the Universim quirkily calls Nuggets, and they can build cities and fight battles of their own accord. However, they'll remain stuck in the Stone Age unless you gently prod them towards researching new technologies, such as Fire (does fire count as a technology when it occurs naturally? Answers on a postcard). If you can guide them as far as the space age, Nuggets can then colonise systems beyond their home planet.

The god you play can either be the divine equivalent of a fussy housekeeper, constantly fiddling with every last little civilisation, or a distant and mysterious force, doing the bare minimum and allowing your believers to exercise their free will regardless of consequence. It's still fairly early days, but the developers have a clear and detailed idea of the game they want to make. The Universim is expected to launch on Steam Early Access soon.



Slime Rancher

DEVELOPER Monomi Park / **RELEASE** Out now (Steam Early Access)

Slime Rancher is extremely colourful, but it has more goodies up its sleeve than its rainbow palette. Its unique premise sees you building and maintaining a ranch for sickeningly cute, gelatinous alien creatures on a desert planet thousands of light years from home.

There's a vague similarity with sandbox survival games such as Minecraft or the Long Dark, only the emphasis is less on supporting yourself, and more on supporting the slimes you collect and house on your ranch. You need to feed and look after any slimes you capture with your bespoke Vacpac gadget, and each type of slime has different needs and attributes. Some are vegetarian while others are carnivorous. Some specialise in jumping, making them difficult to contain, while others are feral and must be avoided.

The vibrant aesthetics and its unique slant on the survival/exploration sandbox systems on which so many current games rely makes Slime Rancher stand out. It launched on Steam Early Access in mid-January, but it already has two years of development behind it, meaning there's a substantial amount to explore even at this stage. Also, you make money in-game by selling 'plorts', which is Slime Rancher's term for slime poo. That's Game of the Year 2016 in the bag then.



Who's Your Daddy?

DEVELOPER Joe Williams / **RELEASE** Out now (Steam Early Access)

Sitting somewhere between dark comedy and existential horror, Who's Your Daddy? is an asymmetric multiplayer game about the trials of fatherhood. Taking place in a family home, one player assumes the role of a dutiful, loving father, while the other controls a suicidal baby. The baby's objective is to, erm, self-destruct using whatever means are available, while the dad simply has to prevent its offspring from meeting an abrupt end.

The baby can complete its mission using any household object or appliance. Turning on the oven and climbing inside it is a viable tactic, as is sticking a metal object into a plug socket. Meanwhile, the dad's ability to protect his Darwin-spiting child is mostly limited to running around after his spawn and switching off whatever it turns on, or swiping whatever implement it's holding from its stubby fingers and finding a safe place to put it.

Dad can also gain an edge by completing everyday tasks. Putting away all of baby's toys, for example, will grant him X-ray vision, although performing these tasks also gives the baby ample time to do something horrible to itself.

The game's foundation is now pretty much complete, so now the developer is mostly spending its time balancing the Dad's protective abilities against the baby's destructive repertoire.

Binaries

DEVELOPER Ant Workshop Ltd / **RELEASE** 4 April 2016

Ant Workshop's Binaries is a minimalist platformer about controlling a ball through a maze of spikes and obstructions. Sorry, did we say 'ball'? We meant 'balls'.

There are two of them, both of which are controlled simultaneously and they sit in separate puzzle rooms that may not be symmetrical.

It doesn't take long to see the fiendish puzzling potential of Binaries' simple setup, testing your spatial awareness like an eccentric optician in over 100 puzzles of increasing difficulty. To avoid that age-old puzzling problem of becoming completely stuck, Binaries' puzzle map is also non-linear, enabling you to choose your path and circumvent conundrums that bamboozle you for too long. Also, there are jokes, apparently.



The clean and straightforward approach of Binaries looks immensely appealing. It doesn't try to tie its puzzles together with meandering introspection about the meaning of life, as attempted by many indie platformers. The puzzles are there because solving puzzles is interesting, and there are jokes because jokes are funny. Sometimes that's enough. **8/10**

50 TIPS FOR BUILDING A BETTER PC



Whether you're a PC-building newbie or an old-timer, here are 50 tips from Antony Leather, covering hardware, software and simple buying advice, to help you put together a better PC setup

01

SET SATA SSDs TO AHCI

While using AHCI mode for your SATA storage devices isn't a requirement for TRIM to operate and keep your SSD in peak condition, it allows for hot swapping and native command queuing, which can improve performance. Head into your motherboard's EFI by tapping the Del key when the machine

powers on, then locate the storage/SATA section and set your SSD(s) to AHCI mode.

02

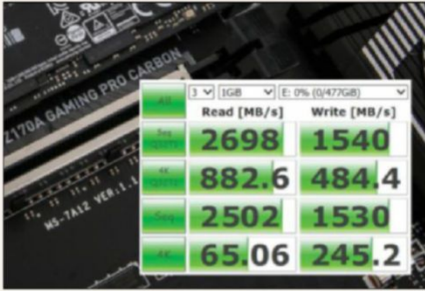
USE INTEL 6GBPS PORTS

Many motherboards have SATA 6Gbps ports powered by third-party controllers, such as Marvell, in addition to those controlled by the standard Intel chipset, particularly on older boards. It's fine to use these third party ports for hard drives and optical drives, but



they'll limit the performance of fast SSDs. The Intel ports will allow them to reach their maximum speed, but using other ports could see speeds reduced from 500MB/sec to less than 300MB/sec. Look in your motherboard's manual to see which ports are the Intel ones and hook them up to any SSDs.





03 GET THE RIGHT M.2 SSD HARDWARE

If you're buying new M.2 SSD hardware, make sure that both your SSD and your motherboard support the latest 4x PCI-E 3 NVMe M.2 standards, and that your motherboard can accommodate the SSD's dimensions. SATA M.2 drives are significantly slower than PCI-E drives, and first-gen PCI-E 2 M.2 setups can't match the pace of the latest 4x PCI-E 3 systems either. Samsung's 950 Pro is a good M.2 SSD, and you can find out what SSDs your motherboard can support in the manual or online specifications. Once your SSD is installed, run CrystalDiskMark (<http://crystalmark.info>) to make sure you're getting the correct speeds. As with all SSDs, make sure Windows and regularly used software are on the fastest drive and not on your hard disk.

04 POSITION DRIVES CORRECTLY

Most cases have numerous 2.5in and 3.5in drive mounts in several locations. Use any 2.5in mounts on the rear of motherboard if they're available in your case, in order to reduce cable clutter.



Position any hard disks with their sockets facing the motherboard tray – not the main side panel, for easier cable routing.

05 REMOVE VACANT DRIVE MOUNTS

Some cases use drive cages to mount hard disks, holding two or more in each one. If you only need one 3.5in mount, or you're an SSD-only system, then remove any unused drive cages. They're often

06 USE ALL THE SCREWS

PCs require dozens of screws to secure your hardware, and even cases that offer tool-free mounts still require screws for the motherboard and PSU. Don't cut corners by not installing all of them. Not only can loose components put stress on your hardware if you move your PC, but they can also cause parts to slip out of their slots.



located at the front of the case next to front grilles and fan mounts, so removing them can improve cooling from airflow, and give you more room for water-cooling gear.

07 USE CABLE-ROUTING HOLES AND CABLE TIES

Your case's cable-routing holes will be positioned in key places, so you can pass various cables through the motherboard tray to your components. Start by feeding all your PSU's cables through the holes next to the PSU mount, before passing them back through to your motherboard and graphics card further up. The 8-pin EPS 12V connector can usually stretch all the way up and over the motherboard tray into a hole at the top. Once you've connected power to all your components, group the cables together and secure them using cable ties to anchor points behind the motherboard tray.



08 REMOVE UNNEEDED FRONT PANEL CABLES

Decide if you'll be using the front-mounted audio or USB ports on your case. For instance, if you're using a USB hub, or if your case is positioned under your desk or somewhere else that isn't within easy reach, you may not need them. Likewise, if you don't have an analogue headset, you may not need the audio connectors. See if you



can remove the connectors from the front panel PCB inside your case. Many will be secured using screws, or simply connected to the front panel PCB. Removing these cables can save some cable-tidying time and reduce clutter if you don't need them.

09 POSITION FANS CORRECTLY

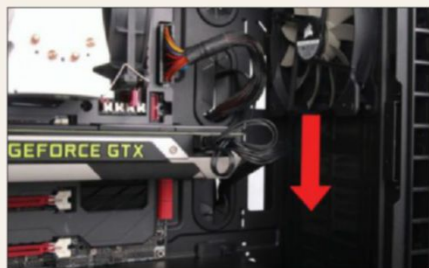
If you're installing your own case fans, make sure they're pointing in the right direction. They'll only spin in one direction, and exhaust air that way as a result. Most fans have support struts on the exhausting side, and cases usually have a front-to-back airflow direction, so install them accordingly, with the struts facing the rear of the case, unless your case's



airflow system has a non-standard design. Also, rotate the fans so that their power cables point towards their power connectors, keeping them out of sight.

10 POINT INTAKE FANS AT GPU COOLER

Graphics cards are usually the loudest and hottest components in a PC, so you need to give them all the extra airflow possible. There aren't many ways to get this



extra airflow, but one way is to install intake fans if your case lacks them out of the box. While it's more important to exhaust hot air out of the back of your case, intake fans make a significant contribution to lowering your graphics card's temperatures. If possible, position your intake fan so that the top of the fan is level with the top of the graphics card, focusing the air towards the graphics card cooler.

11 ALWAYS HAVE AN EXHAUST FAN

As we mentioned in the last step, it's more important to get hot air out of a PC than to get cool air into it. This is because exhaust fans can still draw cool air through



12 POINT CPU FAN IN RIGHT DIRECTION

Modern cases usually at least include an exhaust fan – if you're using a standard tower CPU cooler, the combination of both fans working together can dramatically lower your CPU temperature. As such, make sure your CPU cooling fan is pointing its airflow towards your exhaust fan. In some setups, you may need to rotate the CPU cooler or move the exhaust fan (to the roof of the case, for example) to get the two fans to work together properly.



vents in the case by creating negative air pressure, but using intake fans on their own can result in heat building up inside the case with nowhere to go. Removing the hot air should be your first priority – if your case only has one fan, install it as an exhaust.

13 USE MODULAR PSU

Modular PSUs can have longer chassis than their captive-cable counterparts, but they're otherwise easier



to install and you can also purchase pre-braided cable sets in a variety of different colours. Best of all, though, you can remove the cables you don't need to reduce the amount you need to tidy. Less clutter also means you'll benefit from less airflow restriction, potentially lowering your PC's temperatures.

14 POSITION STANDOFFS CORRECTLY

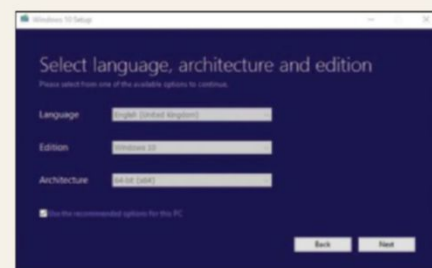
Your motherboard is raised above the metal motherboard tray to prevent the solder points from short-circuiting on the metal, which is obviously important. However, some cases require you to fit the standoff yourself, while others are built



ready for your motherboard to be mounted. If your case needs standoffs to be installed, they will be provided in the package. Line up your motherboard over the tray, identify the holes you need and insert the standoffs into these holes only. Remove any pre-installed standoffs that don't match up with a motherboard screwhole too.

15 INSTALL WINDOWS FROM A USB DRIVE

The days of Windows installations taking hours are over. Installing Windows 10 using a USB stick can be achieved in less than ten minutes if you use its Media Creation Tool to create a thumb drive installer. Download the tool from <http://tinyurl.com/W1otool> and use



a 4GB or larger USB 3 thumb drive. Insert the thumb drive, boot your PC and identify the key you need to press to temporarily change the boot device to your thumb drive (often F10). Once Windows is installed, go to www.ninite.com to select all the programs you use, and download a file to automatically install them for you, saving a lot of time.

16 CLEAN DUST FILTERS AND FANS

Like it or not, your PC will attract dust, so using dust filters is important. However, it's just as important to clean them regularly to prevent them becoming clogged, after which your fans will have to speed up to keep your hardware cool. The best tool to use is a vacuum cleaner with a brush attachment, as it will remove the dust and suck it up at the same time, rather than spreading it around the case or creating a mess.





17

SET MEMORY CORRECTLY

By default, your memory will run at SPD speed (set by a chip on the DIMM), which is usually much slower than its top-rated frequency and timings. If your memory has an XMP profile, then press Del to go into your EFI at startup, find the advanced settings and enable the XMP profile, which should apply the correct frequency, voltage and timings for your memory – they're usually listed on the side of the modules. If the XMP profile doesn't apply the correct settings, you'll need to delve a little deeper into the EFI and apply the correct settings yourself.



18

USE CPU FAN HEADERS

Unless you're carefully tuning the voltage of all your fans yourself (see step 21), any fans that are cooling your CPU – whether they're mounted to heatsinks or radiators – should be connected to your motherboard's CPU fan power headers. They don't need to run at 12V or maximum speed all the time, and these headers usually have PWM (pulse width modulation) control, so they can automatically wind down the fan speed in low-load situations, reducing noise.

19

CONTROL CASE FANS WITH MOTHERBOARD

Reducing your case fans' speed can be as easy as using your motherboard's fan headers, especially with modern enthusiast boards. Most boards can now control the speed of 3-pin fans so long as they have the full three cables. Check the



fan profile setting in the EFI, as you can usually reduce the speed to a percentage or specific profile.

20

REMOVE PROTECTIVE FILM

Many manufacturers apply a plastic film to the contact plates of heatsinks and waterblocks to protect them from scratches, and prevent oxidation of the metal surfaces between the time of manufacture and you installing them. It can be easy to miss this film if you're not paying much attention to the



instructions, and want your PC up and running quickly, but leaving it on can have dire consequences, usually resulting in your system shutting down due to the CPU overheating. Make sure you remove it before you install your cooler.

21

USE FAN CONTROLLERS AND/OR 5V/7V POWER SPLITTERS

Your motherboard can actively control fans using PWM, but the noise can be annoyingly distracting when they regularly spin up and down. It's possible to reduce the speed of the fans permanently using a fan controller, or using simple 5V or 7V fan cables, which can result in a warmer PC at load, but makes it consistently much



quieter. There's rarely much difference between medium and full speed when it comes to case fans, and you can even try limiting your CPU fan to 7V too. Before settling on your fan speeds, though, test your tweaking thoroughly by loading the PC with Prime95's smallfft test (<http://tinyurl.com/prime26-6>) and Unigine's Valley benchmark (<https://unigine.com>) at the same time, to make sure your system is stable and not overheating.

22

USE LARGE FANS

There's a reason why case fans have become larger over the years, which is that they generally provide more airflow while making less noise – you can safely apply less voltage to a larger fan than a smaller fan, but get similar airflow, resulting in less noise. Their use makes

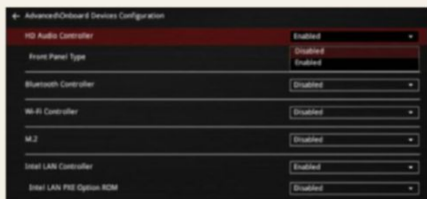


sense even in small cases too. If you have the option of using 140mm fans instead of 120mm fans, then do it. If you're lucky enough to own a case that supports 180mm fans then SilverStone's Air Penetrator fans are an excellent choice too.

23

DISABLE PORTS AND CONTROLLERS YOU DON'T NEED

Motherboards come with a vast array of features, including many on-board controllers and devices. Having all these devices enabled can increase boot times and even cause device conflicts with hardware you've installed. Thankfully, it's easy to disable unused ports and controllers in the EFI. Pay particular attention to third-party SATA controllers, such as ASMedia ones (leave the Intel ones alone), and disable the on-board sound if



you're using your own sound card. You can also disable eSATA, FireWire and other data ports if you don't use them.

25 CHANGE CPU COOLER

Many cheap PCs come with the CPU manufacturer's stock cooler. While these coolers are better than the terrible stock coolers of the past, many third-party coolers offer better cooling and significantly lower noise levels too. Even a relatively cheap model such as SilverStone's Argon, which costs less than £30, will result in noticeably lower noise and temperatures on an LGA1151 or LGA1150 system.



26 USE LED STRIPS

Illuminating your PC can dramatically liven up its appearance and add some pizzazz to an otherwise dark interior. Adding LED strips is easy and they're available in a range of colours. They come in magnetic and self-adhesive flavours, depending on whether you have a steel or aluminium case and, in the case of NZXT's Hue+ lighting system, they can even offer the full RGB colour spectrum across several strips, complete with lighting effects too. Position them where they won't dazzle you, and locate them out of sight near to a side-panel window for the best results.



27 BUY THE BIGGEST SSD YOU CAN AFFORD

SSDs are getting cheaper all the time, but it's better to go for a slower, larger SSD than a ridiculously fast one that leaves you constantly juggling for free space. The



24 OVERCLOCK YOUR GRAPHICS CARD

Applying a small overclock to your graphics card usually won't result in system instability and can give you a healthy performance boost in games. Download MSI Afterburner from www.guru3d.com and identify the GPU and memory clock speed sliders. Now download Unigine's Valley benchmark from <http://unigine.com>, which you can use to stress-test your overclock and check temperatures. Increase the core and memory speeds by 30MHz, and boost the power and temperature limits to maximum. If these settings are stable after 15 minutes of running Valley, and your GPU temperature doesn't rise above 90°C, you can try increasing the frequencies in small steps, watching for stability issues.



jump in performance from a hard disk to an SSD is always much bigger than going from a low-end SSD to a high-end one. Aim for at least 256GB in size – any less and just installing Windows 10 and a few big games will leave you short on space.

28 BUY A G-SYNC MONITOR

Great frame rates in games can be marred by tearing and stuttering artefacts, which are caused by your frame rate being out of sync with your monitor's refresh rate – a hangover from the CRT era. As such, one of the best gaming upgrades you can make at the moment is an active sync display, which locks the refresh rate in sync with your frame rate, eliminating tearing and stuttering – the visual difference it makes is amazing. Monitor's based on Nvidia's G-Sync tech are pricier than those based on AMD's FreeSync, but G-Sync is the superior tech, as it continues to work at lower frame rates, while lots of FreeSync monitors stop actively syncing below 30fps. As well as a G-Sync monitor, you'll also need a compatible Nvidia GPU, however.



we'd advise saving some money and buying a better SSD or monitor instead. Equally, if your monitor's native resolution is 2,560 x 1,440, you'll be best off with a GeForce GTX 970 or 980, while you'll need at least a GeForce GTX 980 Ti or a Radeon R9 Fury X (or ideally a dual GPU setup) to get playable frame rates at top settings at 4K.

30 DON'T BUY AN UNNECESSARILY EXPENSIVE CPU

Hyper-threading is all very well, and can be worth using with cheap dual-core CPUs to provide extra grunt in multi-threaded tasks, but the extra £100 you'll spend on a Core i7-6700K over a Core i5-6600K is only worth it if you do a lot of rendering or video editing, and even then you may be better off with a 6-core Core i7-5820K anyway. You'll gain very little, if any, extra performance in games and tasks that don't use more than four cores (which is still most software). That money will be much better spent investing in a larger SSD or a more powerful graphics card.

29 GET THE RIGHT GPU FOR YOUR SCREEN

If your monitor's native resolution is 1,920 x 1,080 then you don't need to invest in a GPU any more potent than a GeForce GTX 960 or a Radeon R9 380, which will provide smooth frame rates in current games with top settings at this resolution. The only reason to go higher is to get yourself some future-proofing, but



31

USE A NAS BOX

Network attached storage (NAS) enclosures can offer an all-in-one way to share your files with other devices around your home, including TVs, smartphones and all your PCs and laptops, as well as allowing you to access your data and stream content over the Internet. Our favourite NAS boxes at the moment come from Synology (pictured), which have a really user-friendly OS and great media transcoding features.



32

REPLACE STOCK GPU COOLER

Your graphics card is, sadly, most likely to be the noisiest component in your PC. Most stock GPU coolers do a good enough job, but they don't cool particularly well, even if they're fairly quiet. However, both Corsair and

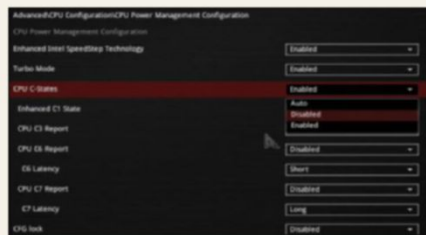


NZXT offer adaptors that allow you to mount their all-in-one liquid coolers to your graphics card. NZXT's Kraken K10 is quiet and cools the GPU very well, while some of Corsair's latest efforts have adaptors for VRM and RAM cooling too.

33

DISABLE CPU POWER SAVING

Your CPU has numerous ways to save power and reduce your



electricity bill, but if you're keen to get the best performance out of your machine and don't mind drawing a little extra power, there are several ways to get some more speed. If you're gunning for high overlocks, it's important to disable settings such as C-state, C1E support and CPU Spread Spectrum in the CPU section of the EFI, as they can affect stability. You'll see a marked performance improvement in some benchmarks if you disable Intel SpeedStep, as you then essentially force the CPU to run at its maximum speed all the time.

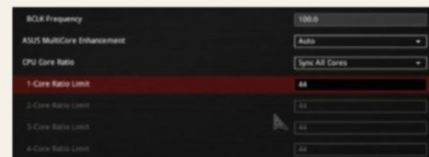
35

OVERCLOCK YOUR CPU

There are two ways to overclock Intel CPUs. The easiest is to use the multiplier, which increases the CPU frequency in 100MHz steps, although this method is only possible on K-edition CPUs. You can access the multiplier setting in your motherboard's EFI (press Del to enter it when your PC first boots), although you may need to set the overclocking mode to Manual first. You'll also need to increase the CPU voltage or vcore, but that's an easy job – you can safely set it at 1.3V for Sandy Bridge, Ivy Bridge, Haswell and Skylake CPUs, and increase the multiplier in single steps to find the maximum stable setting. Use Prime95's smallfft test (<http://tinyurl.com/prime26-6>) to check stability, and CoreTemp (www.alcpu.com) to monitor temperatures, and gradually reduce the voltage until you experience instability.

Base clock overclocking is a recent revelation (very much not endorsed by Intel, as Rich points out on p10), which allows non K-edition Skylake CPUs to be overclocked significantly using the base clock, which wasn't previously possible on Intel's latest CPUs. You need to download the correct BIOS for your board from <http://tinyurl.com/baseclock-bioses> and apply it. Then apply the XMP profile and, on most boards, you'll also have to manually set the multiplier to its maximum default value. On rebooting, you should then be able to increase the base clock by 10-20MHz, resulting in overlocks up to 1GHzMHz on normal systems.

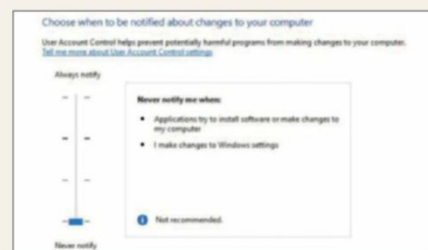
You'll also need to tweak the memory multiplier to align the frequency with the rated one, as increasing the base clock also increases the memory frequency.



36

DISABLE WINDOWS USER ACCOUNT CONTROL

User Account Control can be useful for less tech-savvy users, but it's an annoying hindrance for enthusiasts that pops up when we try to open programs or make changes to Windows. If you know what you're doing in Windows, then disabling it cuts out those annoying pop-ups. Go to the Windows Control Panel (under All Apps in the Windows 10 Start menu) and type 'UAC' – you'll then be able to see User Account Control or Change User Account Control Settings. Drag the slider bar all the way down to Never Notify and click OK.



34

GO BEYOND HD

The faithful HD 1080p resolution has served us well, but you can now snag yourself even more pixels with even a modest budget, making games look even sharper, and giving you a greater pixel density on the Windows desktop, resulting in more workspace and smoother text. Even mid-range GPUs can cope with games at 2,560 x 1,440 now, so there's little to prevent you from going beyond HD. You also have fantastic super-wide and 4K monitors at the top end of the spectrum. If you're buying a new monitor, though, our advice is to buy one with an IPS panel, rather than a TN one, as they offer superior colour reproduction and viewing angles, and they've started plummeting in price recently.



37

UPDATE GRAPHICS DRIVERS

Old graphics drivers can cause stability issues as well as making your games run slower. New drivers are continually released, which improve performance and iron-out bugs. Head to



www.geforce.co.uk/drivers for Nvidia GPUs and <http://support.amd.com> for AMD models to get your latest driver. The latest drivers include Nvidia's GeForce Experience and AMD's Gaming Evolved client, both of which can help to keep your drivers up to date.

38 UPGRADE WI-FI GEAR TO 802.11AC

If you regularly use Wi-Fi at home, then consider upgrading your gear if you currently use 802.11n or older technology. The latest 802.11ac standard

offers better signal strength and far faster speeds too. Some tests we've conducted saw data transfer speeds in excess of 80MB/sec, which could revolutionise how you move your data and stream content around your

home, especially if you use a NAS enclosure or a server.

39 USE RUBBER MOUNTS AND WASHERS

Many premium fans and cases include a variety of anti-vibration gear that can reduce noise, but you can also purchase third-party parts for cheaper cases. These simple rubber mounts and washers do a great job of absorbing the vibrations from mechanical parts, significantly reducing noise. You can mount your fans using rubber fan gaskets (available from www.overclockers.co.uk)

and the mounting pins that come with fans such as Noctua and SilverStone are available separately too, for under £1 from www.quietpc.com. The latter retailer also stocks mounting



washers that can be attached to hard disks to reduce vibration too.

40 USE OTHER PCI-E SLOTS

If possible, use 1x PCI-E slots that are placed above the primary graphics card 16x slot, as you'll then get more space for larger graphics cards, and improve airflow too. Also, it might sound odd, but you can actually put 1x PCI-E cards in 4x and 16x slots, and you can put 4x cards in 16x slots – handy if you've run out of 1x slots in useful places.



42 APPLY THERMAL COMPOUND CORRECTLY

Some CPU coolers have thermal paste pre-applied, but if you're applying it yourself, make sure both the cooler and



41 PUT GRAPHICS CARDS IN CORRECT SLOTS

Always use your motherboard's top 16x slot (the largest type of slot) for your graphics card, as it will be guaranteed to get the full allocation of PCI-E lanes. Using other slots may see that bandwidth reduced, which can impact on performance. Similarly, if you're using two or more graphics cards, consult your motherboard's manual as to which slots you need to use. Intel's mid-range Z170 motherboards offer eight lanes per card for two-way setups, but the bandwidth can drop to four lanes if you use the wrong slot.



CPU surfaces are clean. You can clean them with TIM cleaner or Isopropyl alcohol, using a microfibre or cotton cloth – don't use kitchen towel or tissues, as they can break up, leaving microscopic fibres on the surfaces, hindering cooling. When the surfaces are clean and dry, apply the thermal paste across the middle of the CPU in a cross shape using thin lines. When you install the cooler, the pressure will spread the thermal compound effectively where it's needed, without you needing to spread it yourself.

43 INSTALL RAM IN RIGHT SLOTS

Dual and quad-channel memory modes are available on most modern motherboards and will increase your bandwidth via interleaving, which is particularly important if you're using an AMD APU or relying on Intel integrated graphics. Make sure you insert your memory modules into the correct slots to enable this mode. For dual-channel motherboards with four slots, the second slot should always be populated (important if you're testing with one module). Your motherboard's manual will tell you where to insert the modules. It's also a bad idea to install one module now with a plan to upgrade later – doing so will run your memory in single-channel mode, which can impact on performance, and there's also no guarantee that a new module will properly cooperate with the original one – memory makers sell their memory in matched sets that are guaranteed to work together.



44 INSTALL PSU CORRECTLY

Cases have a variety of PSU mounts. In the base of the case, the PSU usually points downwards, making



use of a specially made vent to draw in cool air and usually a PSU dust filter too. Occasionally, though, the PSU points up into the case – it all depends on your case's airflow design – make sure you check the orientation in your case's manual. PSU mounts in the roof of the case almost always have the PSU fan facing downwards so that it can draw air from within the case and expel it out the back.

45

GET A SEMI-PASSIVE PSU

Many super-efficient PSUs can operate their fans semi-passively, meaning they actually switch them off at low loads for silent running. This low-noise operation can be great if

you're typing or browsing the Web.

What's more, well-made semi-passive fans such as Corsair's RM series still

remain exceptionally quiet when the fan spins up as well.



46

DON'T REMOVE YOUR SIDE PANEL

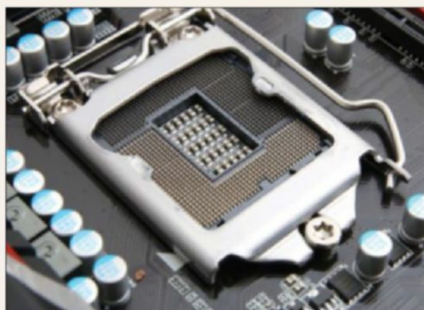
A decade ago, removing your side panel was a popular trick to boost cooling in the summer, but these days there's little need, as case cooling is much better, and by removing the side panel, you're effectively messing up the internal airflow system. You'll be at risk of clogging your PC with dust in a matter of weeks, as well as having spiders making their homes in there.



47

BE CAREFUL WITH CPU SOCKET PINS

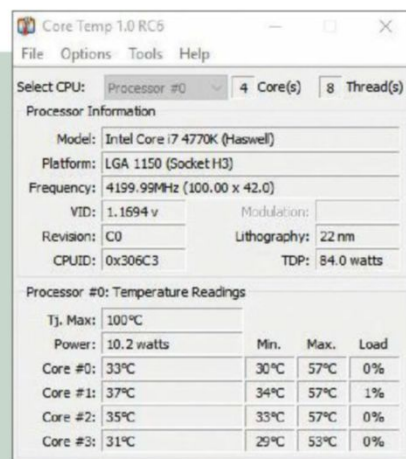
While Intel's CPUs lack the delicate, bendable pins of AMD's CPUs, Intel systems have their own chink in their armour. The CPU socket pins on motherboards are incredibly fragile, and bending them can often result in a dead motherboard. Even dropping the CPU into the socket from a few centimetres above the socket can render your motherboard useless. Be extremely careful when installing your CPU, orientating the CPU so its shape matches that of the socket, then moving it over the socket at a low height, to minimise the chance of damaging the pins if you drop it.



48

USE THE BEST CABLE FOR YOUR MONITOR

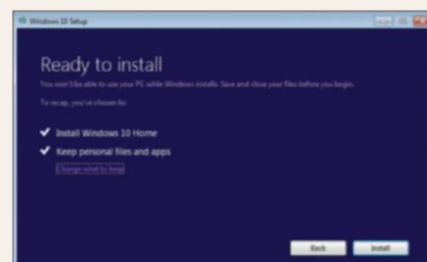
For standard systems with one 1080p monitor, DVI, HDMI and DisplayPort will result in identical images on the screen. For audio to be transmitted to the monitor speakers, you'll need to use HDMI or DisplayPort (or in some cases, a DVI cable will work with an HDMI adaptor). For resolutions of 2,560 x 1,440 and above, you'll need a dual-link DVI cable, DisplayPort or HDMI cable. Display features such as Nvidia's G-Sync, as well as 4K displays, require specific cables too; DisplayPort 1.2 is needed for G-Sync and 4K, although HDMI 2 cables can also handle 4K monitors, along with an HDMI 2-compatible source.



49

MONITOR TEMPERATURES AND PERFORMANCE

Give your PC an MOT every few months to check it's still performing as you would expect. Download CoreTemp (www.alcpu.com) and GPU-Z (www.techpowerup.com). CoreTemp will tell you the temperature of your CPU cores and GPU-Z does the same for your graphics card. Now grab Prime95 26.6 (<http://tinyurl.com/prime26-6>) and Unigine's Valley benchmark (<https://unigine.com>). Run the smallfft test in Prime95, and allow Unigine Valley to run at default settings at the same time. This combination will load your PC to mimic games and high-load tasks. CPU and GPU temperatures above 90°C are too hot, so if your parts are getting toasty, clean your system, buy better cooling or use a lower overclock. You can use Unigine's benchmark mode and our own CPC RealBench 2015 tests (<http://tinyurl.com/cpcrealbench>) to see if your system's speed meets expectations too.



50

UPGRADE TO WINDOWS 10

While Windows 10 has had a rough ride as far as privacy and updates are concerned, it's now possible to deal with most of these issues during installation by unticking certain boxes. It's otherwise a joy to use; you get the Start Menu back, it's fast, installs very quickly, and has numerous new and improved features compared with Windows 7 and Windows 8.1. It's free to upgrade from Windows 7 and 8 until 29 July, 2016. **GPG**



GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

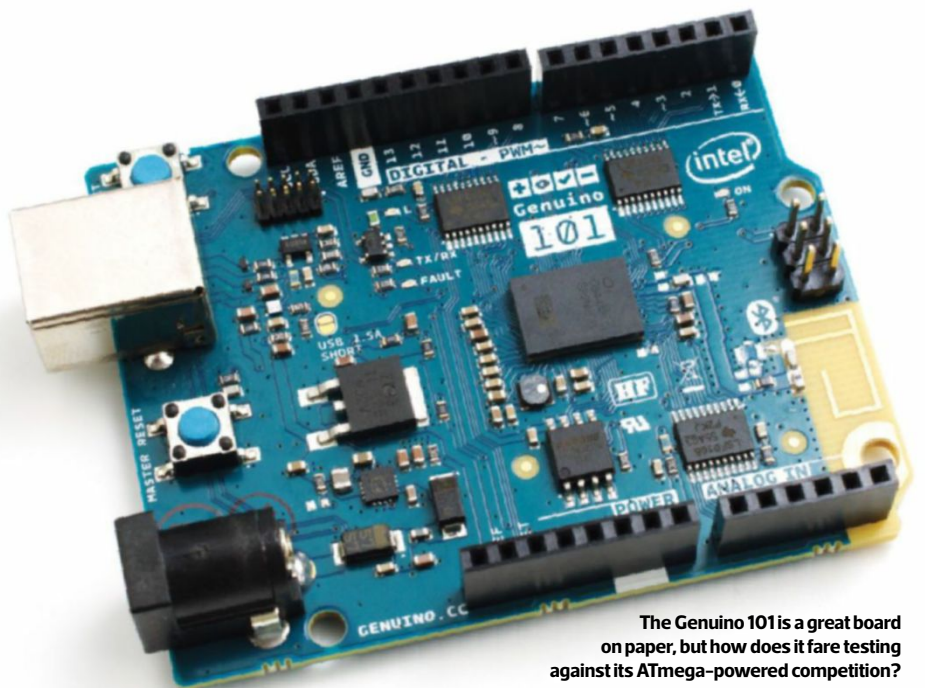
REVIEW

Intel Genuino 101

It's no secret that Intel has been trying to break into the maker market. The company's Quark chip, a process shrink of the ancient Pentium microarchitecture, proved a poor alternative to mainstream microcontrollers in the Galileo (see Issue 128). Then its successor, the Edison (see Issue 141), paired the Quark with an Atom core in an attempt to rectify performance issues, but lost out to rivals thanks to a maker-unfriendly form factor and high-density connections. Will Intel's third attempt, the Genuino 101, finally win over the maker community?

While Intel's previous attempts were 'Arduino Certified' devices, the 101 is an actual Arduino: in the US, it's known as the Arduino 101 while it gets the Genuino 101 moniker overseas thanks to the ongoing trademark dispute between Arduino.cc and Arduino.org (see Issue 142).

It's good to see Intel ditching its attempts to reinvent the wheel, and instead opting to massage its new button-sized Curie computing module into the Arduino Uno form factor. Unlike the Edison, which required a bulky breakout board to make it suitable for amateur use, the Genuino 101 is as amateur-friendly as any Arduino. It's even compatible



The Genuino 101 is a great board on paper, but how does it fare testing against its ATmega-powered competition?

with existing Shield devices, although its use of 3.3V logic with 5V overvoltage protection means that any marginal components that fail to trigger on a 3.3V 'high' signal won't operate as expected.

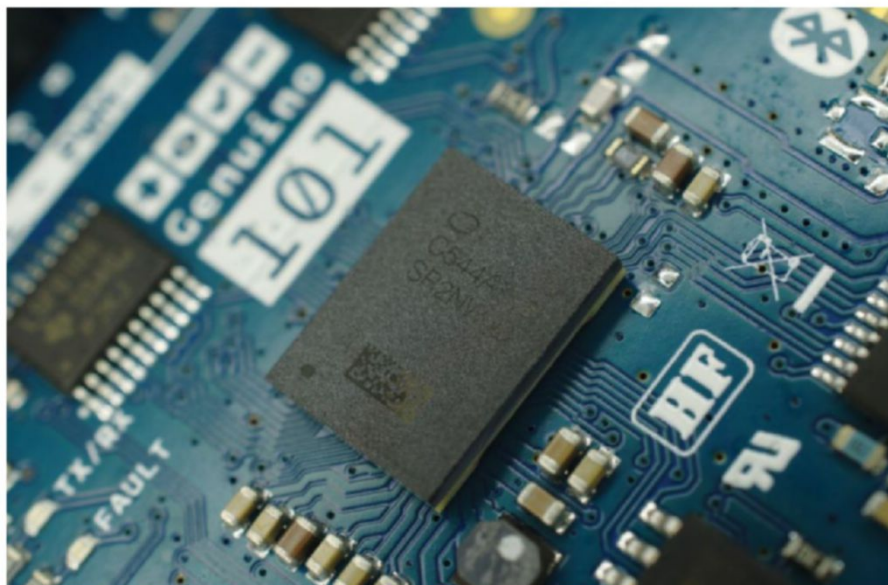
For Intel, though, the decision must have been tough; a quick glance at the spec sheet –

or even the company's selection of example projects – shows that the Curie module, with its integrated accelerometer, is designed with wearable computing tasks in mind.

The Uno form factor is many things, but it's far from well suited to wearable projects. I wouldn't be surprised to see the Genuino 101



Intel has abandoned the 'certification' approach with the Genuino 101; it's a fully fledged Arduino board



The true power of Intel's Curie module won't be apparent until the company releases the RTOS source code

followed by a Flora-style wearable equivalent in the near future.

As with the Edison, the Genuino 101 sees the Quark paired with a secondary processor; while the Atom was used to work around the Quark's poor general-purpose performance on the Edison, this time it plays the role of central processor with an Argonaut RISC Core (ARC) – an architecture originally developed for use as the Nintendo Super FX chip, fact fans – acting in the role of microcontroller.

The split is invisible to the user; the Quark core runs a real-time operating system (RTOS), which handles the on-board Bluetooth radio and other, as yet unspecified, tasks. The ARC, meanwhile, is what runs your Arduino Sketch once it's been uploaded. Intel

promises to release the source to the RTOS in March, which may allow you to run your own code on the Quark; for now, the ARC is the only core accessible to end users.

Having been disappointed by the I/O performance of the Quark in the Galileo – and amused by Intel's tacit admission that it was a poor fit, as evidenced by the presence of the ARC in the Genuino 101 – I was eager to put the Curie through its paces. Having put together a benchmark suite (see p98 for more details about this), I put the Genuino 101 head to head against an Arduino Nano, which is based on the same ATmega328 microcontroller as the popular Arduino Uno.

The switch to the ARC core has certainly helped the I/O performance; the Genuino 101

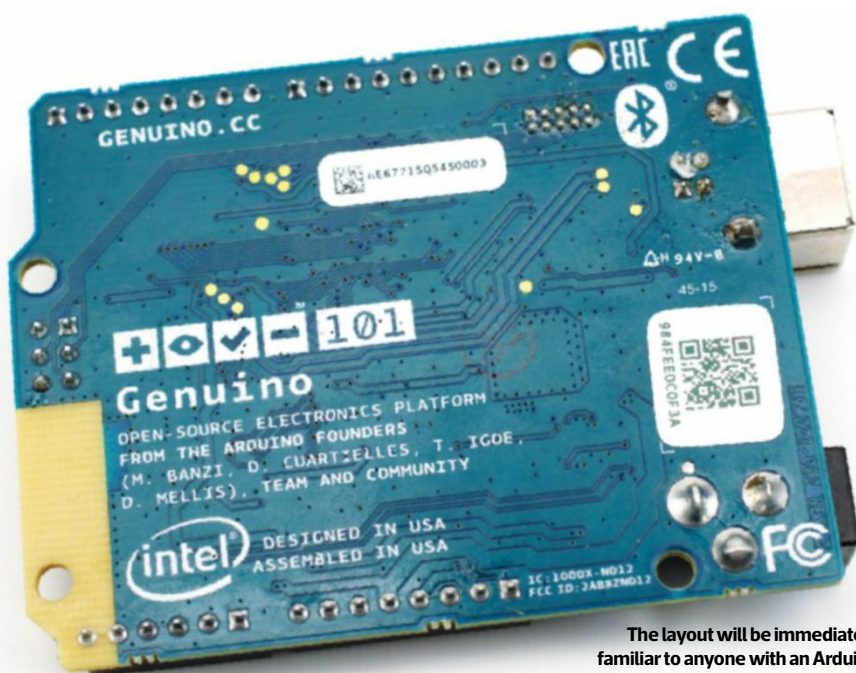
was able to switch a digital pin on and off at a frequency of 169.9kHz, compared to the Nano's 94.1kHz. Integer performance measured considerably higher too – the Genuino 101 ran through Dhrystone at 27.69 MIPS while the Nano hit a peak of 6.25 MIPS (for reference, my accelerated Amiga A500Plus gets 0.58 MIPS).

Floating-point, though, is a different story. Using the single-precision Whetstone benchmark – as the 8-bit ATmega328 is incapable of double-precision – the Genuino 101 manages 0.765 MIPS compared to the Nano's 1.17 MIPS.

Given how the ARC processor smokes the ATmega328 in other tests, this performance difference may be addressed in future software releases, but it's currently worth bearing in mind if you're relying on floating-point arithmetic in your projects.

That's not to say there aren't reasons to use the Genuino 101. The on-board accelerometer is neat, if a little wasted in the Uno form factor, and the Bluetooth Low Energy (BLE) radio is easy to integrate into sketches, although there's no handy smartphone app yet available for experimentation. One major advantage of the Genuino is also the memory – while the Uno has 32KB of flash memory and 2KB of SRAM, the Genuino 101 packs in 196KB of flash memory and 24KB of user-accessible SRAM, with the remainder of the Curie's resources going to the RTOS.

The real power of the Genuino 101 won't be unlocked until Intel releases the RTOS source and allows more control over the Quark processor, though, so let's hope that happens on schedule. The Genuino 101 is available from <https://shop.pimoroni.com>, priced at £28 inc VAT.



The layout will be immediately familiar to anyone with an Arduino Uno, Duemilanove, or similar device

REVIEW

Proster VC99

I've been using a cheap multimeter from the high street for years, and I'd never really seen a need to change – until I misplaced it in one of the many boxes that resulted from my office move, and then got sick of using the tiny and limited pocket multimeter I picked up a while back. As I'm not exactly being in the right tax bracket for a Fluke, I had a browse around the usual e-tailers for budget-friendly meters, and one model popped to the top of my shortlist: the Proster VC99.

With a price of £25 from Amazon, I wasn't expecting much from the device, but when it arrived, I was pleasantly surprised. The package includes a soft zipped pouch, two surprisingly high-quality test probes, a K-type temperature probe and a pair of pre-installed AAA batteries, rather than the usual 9V battery found in most multimeters. Naturally, there are signs of the device's Chinese origins, most evident in the rather poor instruction booklet and the 'AUTO OFF POWER' marking on the front of the device – a reference to the unit's 15-minute standby setting, which is designed to save battery power and lessen the chance of leakage.

It's easy to forgive these niggles when you see the feature list though. The screen is large and clear, although sadly, it lacks any form of back (or front) lighting, and the central

control knob cycles through the various modes with a satisfyingly tactile clunk. These modes include all the features of my old multimeter: auto-ranging voltage measurement for up to 1,000V AC and 750V DC power; resistance and continuity tests with visual or audible indication; capacitance measurement; temperature measurement; and current measurement on μ A, mA and up to 20A manually selected ranges.

With plenty of functions and hobbyist-level accuracy, the Proster VC99 is easy to recommend

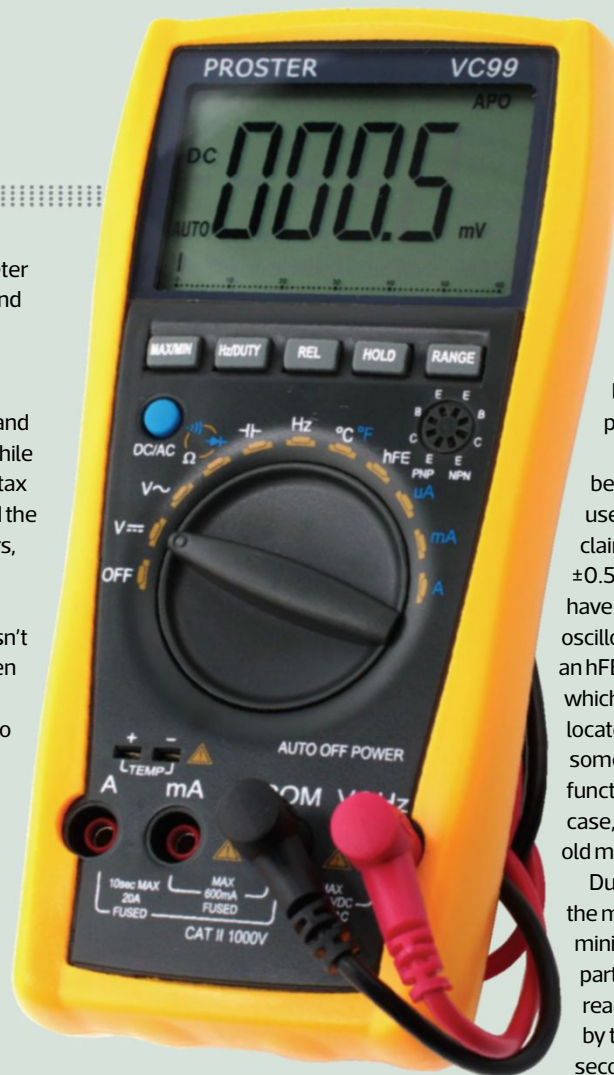
There's a ten-second limit on the latter, indicated by a warning on the probe connection.

There are a few extras above and beyond a normal multimeter too: most useful is a frequency counter mode, claimed to be good to up to 60MHz with $\pm 0.5\%$ accuracy, which means I don't have to dig out my awkward pocket oscilloscope for simple jobs. There's also an hFE test for PNP and NPN transistors, which uses a built-in multi-pole port located above the right of the control dial; some other multimeters offer the same function via a separate adaptor; in my case, I lost this soon after I purchased my old multimeter.

During measurement, you can switch the multimeter to maximum and minimum reading modes, which is particularly useful for detecting spikes in readings (although this feature is limited by the rate of three samples per second). If you freeze the display on your present measurement, for certain tasks you can even switch the multimeter into relative mode. This latter feature is handy when trying to take accurate measurements of resistance. Begin by shorting out the probes to measure the resistance of the test cables, then hit the REL button to have this measurement automatically subtracted from your final component measurement. This process will save a bit of mental arithmetic and/or reaching for a calculator to get an accurate final reading.

With multimeters, though, you're not typically paying for features; you're paying for accuracy. Much of the purchase price of a Fluke, or a similar device, goes into the little bit of paper assuring you that it's been tested to within a certain tolerance, and professional users will regularly send their devices back to the factory for recalibration – often on an annual basis – to ensure the accuracy isn't slipping.

At £25, the Proster VC99 comes with no such certificate, and its official accuracy ratings – ranging from $\pm 0.5\%$ for frequency readings and going as low as $\pm 3.5\%$ for capacitance – may be too low for professional use. However, the readout



The kickstand and probe holder could do with work, sullyng an otherwise pleasant user experience

Having long lost the transistor adaptor for my old multimeter, it's a bonus to have one built into the VC99



The central control knob cycles through the various modes with a satisfyingly tactile clunk

on my unit proved entirely accurate when connected to a calibrated DC power source.

If you're a professional, though, you're hardly in the market for a £25 multimeter, and you probably have a better source of recommendations than this Hobby Tech column. For hobbyist use, most of the complaints you could level against the Proster VC99 melt away when you remember how little you spent on the device.

Not all of them though. While the yellow plastic jacket has a section for probe storage, a slight tug on the cable is usually enough to prompt the nestled probe to pop out. The kickstand has a poor design too, and often slips during use, while lacking the multiple locking angles of some other high street multimeters.

If I were using the Proster every day, these otherwise minor issues would probably drive me to distraction. However, for the occasional user, or as a cheap secondary multimeter for someone who doesn't want to get their Fluke dirty, I'd highly recommend the Proster VC99 or its cheaper stablemate, the VC97. The Proster VC99 can be bought online from www.amazon.co.uk for £25, while the VC97 has a price of £20.



For under £25, getting a bag with the Proster VC99 – even a low-quality one – was a pleasant surprise

NEWS IN BRIEF

Maker Faire UK 2016 prepares for visitors

Described, entirely fairly, as 'the greatest show and tell on Earth', the Maker Faire franchise – created by the people behind 'Make:' magazine – spans the globe, including the UK. I'll be attending both days of this year's UK event, which takes place on 23–24 April at the Life Science Centre in Newcastle, and I'd love to see you guys there. You can find out more information from www.makerfaireuk.com, and buy tickets for £12 a pop (£7 for children, or free if under four years old).



TESTING

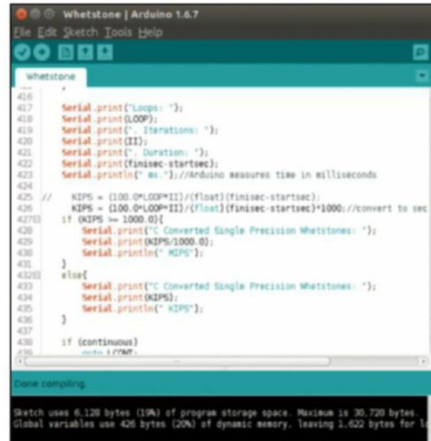
Benchmarking microcontrollers

Reviewing a new microcontroller, as on p94, brings some interesting challenges. Reviewing a Windows PC has a fairly defined process: poke around inside and outside to get a feel for the build quality, run the in-house benchmarks, add the results to a spreadsheet for comparisons and potentially have a crack at overclocking it.

Microcontrollers, though, are different beasts. An obvious starting point is to compare features: ask how many I/O pins it features, what resolution is offered by its analogue to digital converter (ADC), whether it's 5V-safe, whether the toolchain is simple enough and so on. That gets you started, but in the case of the Genuino 101 versus the Arduino Uno – or any other ATmega328-based Arduino or clone – it only takes you so far.

What we need, of course, is a benchmark suite, as we use for PCs. With between 2KB and 80KB of RAM on your average Arduino-compatible device, though, PCMark isn't an option. My natural thought was to use the classics: Whetstone and Dhrystone. Whetstone was developed back in 1972 by B.A. Wichman as a measure of a computer's performance, focusing on floating-point arithmetic; Dhrystone followed in 1984 when Reinhold P. Weicker found himself in need of a similar means of measuring a computer's performance for integer-based arithmetic.

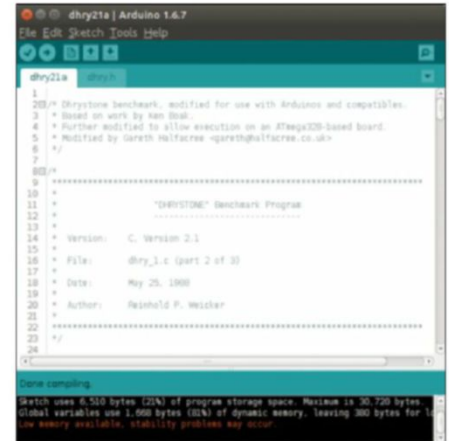
The older benchmark, Whetstone, sits inside an ATmega328 microcontroller quite easily with room to spare, and the work had



Aside from modifying it for single-precision, getting Whetstone to run on an ATmega328 proved easy

already been done for me. Thomas Kirchner had ported the software to the Arduino's particular implementation of C, and I only had to modify the program slightly to use single-precision variables and compile correctly in the latest 1.6.x branch of the Arduino IDE.

The switch from Kirchner's double-precision implementation to single-precision came about as the result of a suggestion from my friend, Paul Brook, after finding that the ATmega328 was punching well above its weight. It turns out that this humble little 8-bit microcontroller can't actually do double-precision, but instead treats 'doubles' as single-precision 'floats' while the 32-bit Curie module correctly offers both single- and double-precision modes.



Dhrystone's high memory use required some clever trickery to make it fit into the 2KB ATmega328

Dhrystone brought its own challenges. As with Whetstone, I found a version that had been ported to Arduino – this time by Ken Boak – but it had a caveat: the memory requirements meant it simply wouldn't fit into the 2KB of SRAM offered by the ATmega328.

That sounded like a challenge, so I began modifying the code as much as possible without affecting the performance of the benchmark. Mostly, this process involved wrapping printed strings in the F macro – `Serial.println("Hello");` becomes `Serial.println(F("Hello"))`; – to move them from SRAM into the chip's more capacious flash memory.

With copies of Whetstone and Dhrystone successfully running on both microcontrollers, I had a way of measuring the floating-point and integer performance. Unlike PCs, though, microcontrollers are typically used to 'toggle pins on and off' calculations, rather than calculating Pi to a billion decimals, so how could I measure the rate at which the pins where being toggled on and off?

Quite easily, it turns out: my new multimeter (see p96) has a frequency measurement mode. With a simple sketch written to turn a pin on and off with no delay, I was able to measure the rate at which it happened – the final piece of the benchmark puzzle. While I may add more tests to the suite in the future, at least now I have a better way to compare microcontrollers than simply listing their features. **GPG**

NEWS IN BRIEF

Boldport Club opens for business

Regular readers may remember printed circuitboard artist Saar Drimer of Boldport and his remarkable creations. If so, you may be interested to know that Drimer has launched a new venture, dubbed the Boldport Club, offering members a chance to receive monthly 'projects' – ranging from bare circuitboards to a revised version of his popular Cordwood puzzle kit – for a regular subscription fee. Pricing has yet to be determined, with a three-project beta programme open now priced at £49 inc VAT, including worldwide shipping. More information is available at <https://boldport.cratejoy.com>



Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. [@ghalfacree](https://twitter.com/ghalfacree)

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ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Hands on with Bitspower's X99E-ITX/ac waterblock

As I mentioned in last month's column, Bitspower has released a full-cover waterblock for the only LGA2011-v3 mini-ITX motherboard on the market – the ASRock X99E-ITX/ac, and this month the company was kind enough to send me one. ASRock pitched in with the motherboard too, so I set about seeing how well the two parts worked together.

Given that the motherboard is close to bulging with all the ports and features squeezed onto it, it's amazing that anyone attempted to water-cool it, so it isn't surprising that Bitspower didn't make a single-piece waterblock for it, which is the usual method for making a full-cover mini-ITX waterblock. Instead, it's used separate custom CPU and VRM waterblocks,



Separate CPU and VRM waterblocks attach to the PCB, which are then linked with a pass-through section

which attach to the PCB, and the two blocks are linked with a pass-through section. It isn't quite as elegant as most full-cover models – it's taller for starters, but it still looks fantastic on the motherboard.

Bitspower has also had to make a narrow waterblock mount for the motherboard's CPU socket, which still uses the normal LGA2011 threaded holes, but these holes are squished inwards by 10mm or so, meaning normal LGA2011 coolers won't fit. Despite all the obstacles, the CPU waterblock was easy to install and didn't encroach on any ports or slots on the PCB, while also staying well away from the DIMM slots. Meanwhile, installation of the VRM waterblock requires the removal of the chipset and

VRM heatsinks; a simple task that then allows the coolant to flow over both hot spots.

Finally, the pass-through section attaches to the waterblocks using four fittings. These fittings are equipped with rubber seals that press into holes in the pass-through section itself, which is then screwed into place. If you don't like the idea of the pass-through section, you'll also be pleased to know that Bitspower has used standard G1/4in threads for the four fittings, so you can just use your own barbs to manually hook up both waterblocks to your water-cooling system.

The CPU waterblock is also a fully fledged product with a proper internal design, unlike some of the CPU sections found in full-cover blocks, so it should perform nearly identically to a regular standalone CPU block. See www.bitspower.com.tw for more information about the ASRock X99E-ITX/ac full-cover waterblock.

XSPC's Ion pump/res combo

If you've been reading my column regularly, you'll know I have a soft spot for small form factor kit, especially when it comes to water cooling. As such, I was pretty excited when I saw XSPC's latest product – the Ion, which it showed off on its Facebook page recently.





The Ion is a compact pump/reservoir combo that measures just 17cm high and 7.5cm wide (at its widest point). It includes three G1/4in ports as well as a fill port on the top, with a large window for a good view of the inside. It's also not equipped with a standard Laing D5 or DDC pump, but with XSPC's own X20 420 pump, which the company already uses in some of its pump/reservoir combos for drive bays. Best of all, though, it looks great and it can be mounted easily. The window has an attractive bevelled edge, and the interior can be illuminated using an included LED. The Ion's flat sides mean it should be easy to mount in a case anyway, but XSPC also includes a bracket that enables you to mount it to a 120mm fan mount or radiator.

The bracket can be installed above or below the Ion, or by its side, so mounting the Ion should be a simple job wherever your radiator or fan mounts are located. This system also frees up the rest of your case, as you don't need to find somewhere to mount a separate pump or reservoir. As a result, the Ion is potentially very useful in small cases, as you can suspend it from a fan mount or radiator, allowing for a very compact



water-cooling system. I have one en route at the moment, and will be taking a look at it in our next issue, as well as chatting to XSPC.

The Ion measures just 17cm high and 7.5cm wide (at its widest point)

Hex Gear's R80

UK case company Hex Gear wowed us in 2015 with the release of its home-grown R40 micro-ATX case, which was designed for water cooling, and our review of it in Issue 146 saw it gain an Extreme Ultra award.

We've seen a number of high-profile projects involving the case too, including Hex Gear designer Hans Pedar Sahl's own project, which we featured in Issue 150's Readers' Drives section. However, while the R40 is fairly large and clearly has oodles of room for water-cooling gear, it can only accommodate a micro-ATX motherboard.

However, if you don't want to downsize from an ATX rig, but like the look of the R40, then you're now in

luck – Hex Gear has announced its first ATX case, the R80. It's a sizeable beast that weighs a hefty 18kg, but there's scope for building a monster PC inside it as a result. EATX motherboards up to 275mm wide are supported, as well as ATX motherboards, of course, and there's room for eight expansion slots – ideal for multi-GPU systems.

The all-important radiator support includes room for a triple 120mm radiator at the top and a quad 120mm radiator at the bottom – enough for seriously high-end systems. The case itself measures nearly 60cm long and 55cm high, and it includes a huge 185 x 304mm mounting plate for securing pumps and reservoirs.

Meanwhile, clearance for radiators at the top and bottom stands at 60mm, so you can squeeze half-height radiators into both locations with a single row of fans. The base clearance is designed to accommodate a system using all the expansion slots, so if you're not filling every slot, there's potentially room in the base for a double row of fans or a thicker radiator. Hex Gear will also offer optional mounting plates that enable you to use 140mm radiators, although the height of these radiators will be restricted by the motherboard.

It looks like a monster case that sports Hex Gear's unique design touches, although it will set you back £300 for the privilege. We'll hopefully be taking a look at the R80 in the next few months. For now, you can see more information about the new case at www.hex-gear.com **EPG**

The R80 accommodates eight expansion slots – ideal for multi-GPU systems



How to Make an external water- cooling system

Want a truly small water-cooled PC? If you're running out of space, why not build an external loop? Antony Leather shows you how it's done

 **TOTAL PROJECT TIME** / 24 HOURS

Water-cooling choices are frequently limited with small cases. There's often little room for water-cooling gear in mini-ITX chassis, while those that do offer it are often nearly as big as, or even bigger, than micro-ATX cases. If you want to water-cool a truly small mini-ITX case, though, there's another option – mounting your water-cooling gear externally.

You don't have to mount a radiator to the outside of your case either. By creating a mostly external water-cooling system, you can use nearly any case you like. Best of all, you can use quick-release fittings, so you can easily remove the water-cooling system to upgrade it, clean it and swap out coolants. What's more, you can even use a single external system to cool multiple PCs, and store it out of sight under your desk, with just your small PC case on your desk.

TOOLS YOU'LL NEED



Mini-ITX case
(Raijintek Metis) /
www.overclockers.co.uk



Alphacool HF Quick
Release Bulkhead fittings /
www.aquatuning.co.uk



Phobya external PSU
with Molex connector /
www.aquatuning.co.uk



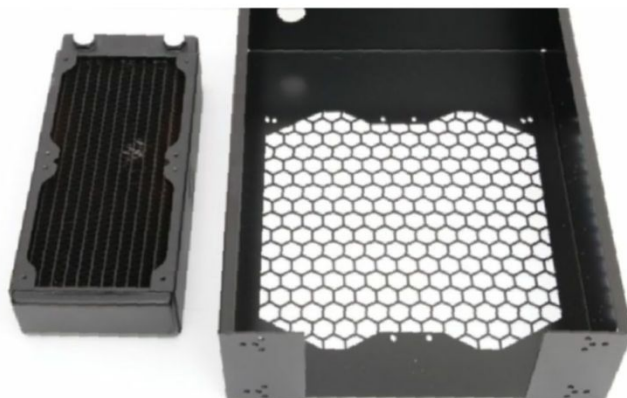
Fillport /
www.aquatuning.co.uk



Phobya radiator stand –
Bench Edition and water-
cooling components /
www.aquatuning.co.uk



Drill and drill bit
and metal files /
Most hardware stores



1 / CHOOSE COMPONENTS

We're using Phobya's 2 x 120mm Bench Edition radiator stand, which can either house two double 120mm radiators internally, with options to mount other gear externally, or a single radiator internally with a pump and reservoir. We've gone with the latter.



2 / IDENTIFY LOCATIONS FOR FITTINGS

We'll be mounting the quick-release fittings to the case using bulkhead fittings, which pass through the case and secure from one end, with the quick-release fitting on the other end. Identify some suitable locations to mount these fittings.



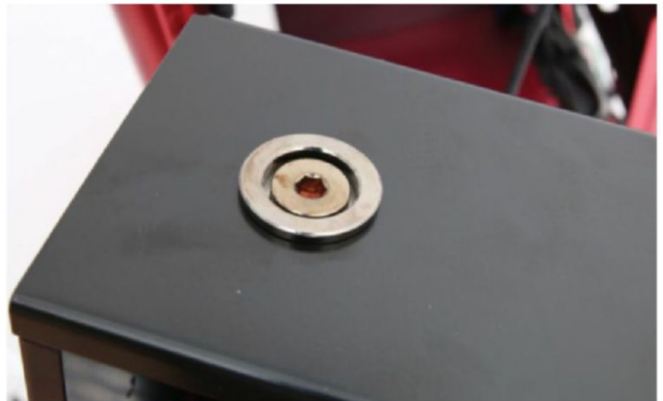
3 / SELECT RADIATOR, PUMP AND RESERVOIR

For modest systems with mid-range graphics cards, a full-height double 120mm radiator provides ample cooling capacity. You can use any pump with the radiator stand, as there's plenty of room, along with a separate reservoir or a pump-reservoir combo.



4 / CONSIDER USING A FILL PORT

The Phobyas Bench Edition stands include a fill port mounting hole, which shouldn't be overlooked, even if your reservoir is easy to fill. Attaching the reservoir to this port can allow for easy and spill-free filling.



5 / INSTALL FILL PORT

The mount is compatible with all fill ports, but you also need to consider where you mount your hardware – it's best for the fill port to sit directly above the reservoir. Detach the locking ring, insert the fill port and then secure the ring from underneath.



6 / INSTALL FITTINGS

Now install all the fittings to the pump, reservoir, radiator and fill port. It's best to do this job outside of the stand, as you can then get a better grip on the fittings to ensure they're tightly fitted.



7 / INSTALL RESERVOIR

If you're using a reservoir that attaches to the fill port, it may be easier to attach the fittings and tubing first, then bring up the reservoir to meet the fill port. The stand has plenty of mounting holes for attaching tube-type reservoirs, which can be secured via the rear.



8 / INSTALL PUMP

It's always best to mount the pump below the reservoir and, in this case, it should be directly below it, as the radiator takes up the other side of the stand. It's worth installing some anti-vibration material between the pump and stand too.



9 / FIT FANS TO RADIATORS

It doesn't matter which side you mount the fans, but you'll likely find it easier to mount them to the radiator first. As the radiator is external, it will be easier to clean than an internal one too – a five-minute swipe with a Hoover will do the trick.



10 / INSTALL RADIATOR

The easiest way to mount the radiator is by passing the included screws through the stand and fans, before securing the radiator. If you want a better view of the fans, you can use standard M3 screws to fit the radiator's rear to the stand instead.



11 / CONNECT TUBING

Now all the components are fixed in the stand, you can install the tubing, using rigid tubing if you like. You'll need tubing that's long enough to reach your case from two of the ports – ideally the pump outlet and radiator inlet – routed through holes in the stand's base.



12 / DISMANTLE QUICK-RELEASE FITTINGS

The quick-release fittings use compression locking rings to secure together. Unscrew these rings and pull the fittings apart. Sprung seals inside the fittings will open up when they're clamped together again.



13 / CONNECT FITTINGS TO THREADS

The quick-release fittings have standard G1/4in ports at either end, so each end needs its own fitting. Go ahead and install your chosen fittings to both the male and female quick-release sections.



14 / CONNECT FEMALE FITTINGS

Connect the two female quick-release sections to the long tubes running from the radiator stand, using the fittings you've attached to them. You just need to release the female sections from the male ones to disconnect the cooling system from the case in the future.



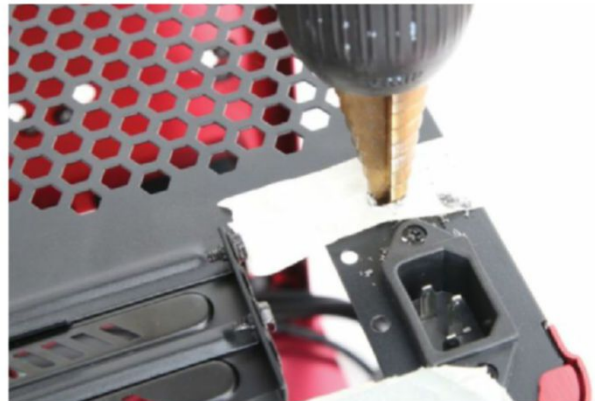
15 / MASK OFF AREA

Drill holes in the case to attach the male sections of the quick-release fittings. These sections have a bulkhead connection, which is essentially a thread cut into the fitting with a locking ring at one end. Mask off the areas where these fittings will pass through the case.



16 / MEASURE BULKHEAD HOLE

Mark a centre point for the quick-release fittings' holes that you need to drill. The holes need to have a 16mm diameter, so make sure there's enough room for both of them, and that they won't stray off a flat section of case.



17 / DRILL BULKHEAD HOLE

Use a 16mm drill bit to create the holes for the quick-release fittings. As the required hole is fairly large, create a pilot hole first using a smaller drill bit. Use masking tape here to prevent you from scratching the case if the drill slips.



18 / FILE HOLE

Once you've drilled out the holes, clear up any metal fragments and use a circular finger file to sand down the hole, removing any loose metal fragments. You want the holes to be as smooth as possible, with no rough or sharp edges.



19 / REMOVE LOCKING RING

The small locking ring needs to be removed before you push the quick-release fitting through the hole, so go ahead and unscrew it from the male fitting. Now push the fitting thread-first through the hole. If it doesn't fit, try filing down the hole a little.



20 / INSTALL MALE QUICK-RELEASE FITTINGS

With the fitting pushed all the way through the hole, and the male section pointing out of the case, secure the fitting by reattaching the locking ring from inside the case. The quick-release fitting is now fixed to your case, allowing coolant to pass through the chassis.



21 / CONNECT INTERNAL FITTINGS

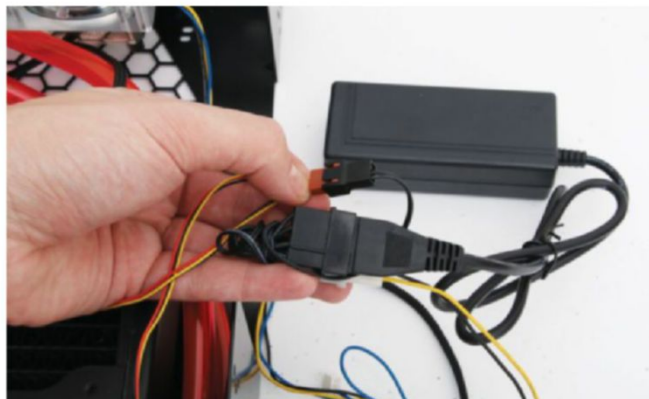
If you're building a new water-cooled PC, go ahead and install all the internal hardware, such as the waterblocks, then attach the hardware's own fittings and connect them with tubing as necessary.





22 / CONNECT BLOCKS TO MALE FITTINGS

Finally, connect either end of the loop to the two quick-release fittings. If you're just using waterblocks in your PC, there's no specific order in which you need to connect them – just go with whatever configuration uses the least tubing.



23 / CONNECT POWER TO PUMP AND FANS

As the pump and fans are far away from the PC, use a Phobya external PSU brick to power them. This PSU provides a single 4-pin Molex plug that can be powered separately from a mains plug. The power limit is 24W – more than enough power for a pump and some fans.



24 / CONNECT QUICK-RELEASE FITTINGS

Connect the male and female parts together, before using the large locking ring to clamp the fitting tight. When you remove them again, there shouldn't be more than a drop or two of spillage, even when the system is filled.



25 / FILL RESERVOIR WITH COOLANT

Go ahead and fill the loop. If you're using the fill port, undo it using the right tool – usually an Allen key, and pour it into a small funnel to prevent spills. Alternatively, open your reservoir and fill it with coolant.



26 / POWER ON PUMP

Go ahead and power on the pump, topping up the coolant as the air is bled from the system. If you're powering on a newly built water-cooled PC, disconnect all the power connectors from the hardware inside the PC first so you can leak-test it.



27 / LEAK-TEST

Add some dye to your coolant if it isn't already coloured, and you can then easily spot leaks by wrapping the joints in white tissue, leaving coloured evidence of any leaks, even slow ones. Leave the system on for 24 hours to make sure it's 100 per cent leakproof. **GPG**

CUSTOM PC

REALBENCH 2015

in association with **ASUS**

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than more CPU cores.

Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake video encoding takes full advantage of

many CPU cores, pushing them to 100 per cent load.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2,400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. **CPC**

SHOUT OUTS!

This month's top shout out goes to new entry Menthol, who's hit the number six spot with his 8-core Core i7-5960X rig, producing a total system score of 211,331. Meanwhile, richardnpaul has improved the score of his Xeon E5 2670 setup to 181,058 at number 12.

Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

CUSTOM PC REALBENCH 2015 LEADERBOARD

RANK	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	275,683	240.9%	8pack	Asus Rampage V Extreme	Intel Core i7-5960X	5.5GHz	16GB Kingston 3000MHz	Nvidia GeForce GTX Titan X
2	233,375	203.9%	ian.parry3	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	32GB G.Skill 3200MHz	Nvidia GeForce GTX Titan X
3	221,477	193.5%	Chris_Waddle	Asus Rampage V Extreme	Intel Core i7-5960X	Not reported	16GB Corsair 2666MHz	Nvidia GeForce GTX Titan X
4	219,415	191.7%	Luke@DinoPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	16GB Corsair 3276MHz	Nvidia GeForce GTX Titan X
5	215,694	188.5%	dubai1	Asus X99-Pro/USB 3.1	Intel Core i7-5960X	4.7GHz	32GB Corsair 2800MHz	Nvidia GeForce GTX 980 Ti
6	211,331	184.6%	Menthol	Asus Rampage V Extreme	Intel Core i7-5960X	Not reported	32GB G.Skill 3200MHz	Nvidia GeForce GTX 980 Ti
7	206,723	180.6%	stuart	Asus Rampage V Extreme	Intel Core i7-5960X	4.41GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 780 Ti
8	201,446	176.0%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.3GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX Titan X
9	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2400MHz	AMD Radeon R9 200 Series
10	189,230	165.3%	shadowrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980
11	185,219	161.8%	dax	Asus Rampage V Extreme	Intel Core i7-5960X	3.97GHz	32GB Corsair 2448MHz	Nvidia GeForce GTX 980
12	181,058	158.2%	richardnpaul	ASRock EP2C602	Intel Xeon E5 2670	3.3GHz	32GB Kingston 1866MHz	AMD Radeon R9 200 Series
13	179,386	156.7%	mboogie	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Crucial 2133MHz	Nvidia GeForce GTX 980
14	175,745	153.6%	dis80786	Asus Rampage V Extreme	Intel Core i7-5930K	4.4GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX 970
15	173,154	151.3%	mark.gee93	Asus Rampage V Extreme	Intel Core i7-5930K	4.49GHz	12GB Corsair 3168MHz	Nvidia GeForce GTX 980 Ti
16	172,828	151%	mdottwo	Asus Rampage V Extreme	Intel Core i7-5820K	4.4GHz	16GB G.Skill 2766MHz	AMD Radeon R9 200 Series
17	167,332	146.2%	grozzie	ASRock X99M Killer	Intel Core i7-5930K	4.48GHz	32GB Kingston 3071MHz	AMD Radeon R9 200 Series
18	167,002	145.9%	maliepaard.chris	MSI X99S SLI Plus	Intel Core i7-5820K	4.49GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 980 Ti
19	165,635	144.7%	mikey	Asus Rampage V Extreme	Intel Core i7-5960X	Not reported	16GB Corsair 2133MHz	Nvidia GeForce GTX 980
20	165,512	144.6%	Penfold	Asus X99-Deluxe	Intel Core i7-5820K	4.5GHz	32GB Corsair 2333MHz	AMD Radeon R9 200 Series

Readers' Drives

Node



Christian Ost 3D-modelled his very own mini-ITX case design in SolidWorks and then had it 3D printed, resulting in this stunning and unique build

CPC: What originally inspired you to build Node?

Christian: The original inspiration came after I used a 3D printer to produce some projects for work, as well as seeing the 3D printer demo models at my local hardware store. A friend of mine also approached me about making a similar project; he wanted a full tower with all the bells and whistles found on modern cases. Unfortunately, after working on the original idea for a few months, the project hit a dead end. A few months later, I pulled up the project files again, and started from scratch on a whole new version of the idea.

CPC: Where did the name come from?

Christian: I was working on the 3D video for this project, and the software I was using to render the video is very CPU-intensive, so I had a number of machines networked together to improve the render times. I thought, 'Hey, this is just another render "Node" in my render farm.' And boom, it just became Node from then on.

CPC: What's Node's purpose as a system?

Christian: This system serves a number of purposes now that it's completed. The first of which is being my new main backup system. I occasionally do work on my main rig, and having Node as a backup up system for gaming, research and so on is a big help when I'm doing different jobs with my main system. It's also replacing my old backup system, which is three or four years old. The second purpose is, as the name suggests, serving as another 'Node' in my render farm if I ever produced more 3D rendered videos in the future. Finally, it serves as an ideal system for friends to play on.

CPC: What specs did you choose and why?

Christian: I needed a fast CPU to help with my rendering work, so I went with a Core i7-4790K, which was the latest and greatest mainstream CPU at the time – it's currently sitting at stock frequencies, but it will be overclocked soon. Meanwhile, the graphics card is an EVGA GeForce GTX 970 SC. I went with this card for two reasons. Firstly, it's a great mid-range card with plenty of power to see me through a few years of gaming. Secondly, it has a short PCB, which means it had a small overall package once I'd fitted a waterblock to it, giving me more room in the case for my other water-cooling components.

CPC: What other mods have you built?

Christian: I've only built one other fully custom PC called VX-42, which is a wall-mounted media/game hosting server. It's made out of wood and aluminium, and I still use it on a daily basis for various jobs,

but mostly for backing up the data on my main system. I've built another PC-related project too, which is a custom-built triple monitor stand called RGD – short for 'rigid'.

CPC: What difficulties did you come across in the build process?

Christian: I ran into a number of difficulties throughout this project, from poor 3D prints to parts not fitting in areas where they should fit. When I start these projects, I usually try to make accurate 3D models of the parts I plan to use, but sometimes you can't find specs or sizes of all the parts. As such, ideas that work in your model might not work in real life. I ran into this issue mostly with the radiators I'd planned to use originally – the ones I wanted to use were too thick when I went to put them in the case, which caused the fans to clash into each other, so I ended up having to use thinner radiators.

CPC: Why did you decide to use 3D printing, and did this decision present any issues?

Christian: I mainly decided to use 3D printing as a materials study, in order to assess its capabilities. I'd known about the technology for a few years, but I'd never built such a large project with it before – I'd just made small pieces here and there. I was tired of seeing trinkets being printed, and I wanted to see if I could 3Dprint a product that I could actually use when it was all finished. However, as with any new and emerging technology, there



/MEET THY MAKER

Name Christian Ost (aka Complx)
Age 26
Location Pennsylvania, USA
Occupation Package designer
Main uses for PC Gaming, design work and rendering
Likes Gaming and racing sims
Dislikes Problems with the projects on which I work



SYSTEM SPECS

CPU Intel Core i7-4790K

Graphics card EVGA GeForce GTX 970 SC

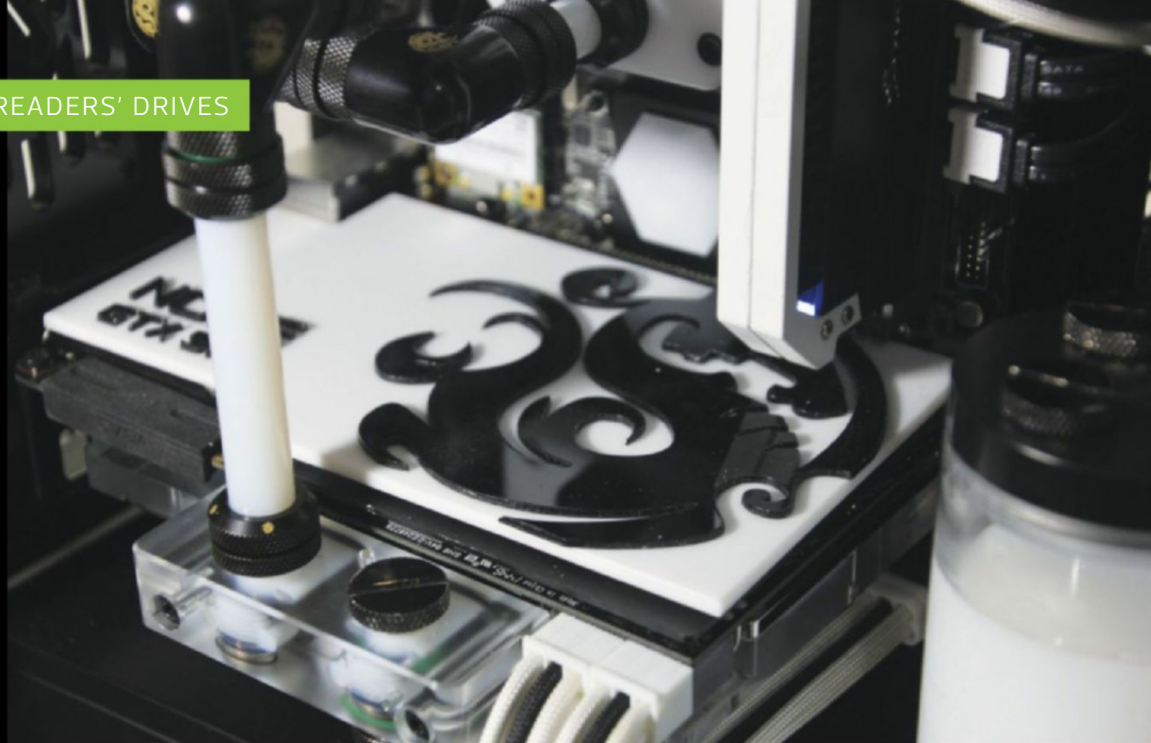
Memory 8GB (2 x 4GB)
Corsair Dominator Platinum
2133MHz

Motherboard Asus Z97I-Plus

Storage 120GB and 250GB
Samsung 850 Evo SSDs

PSU SilverStone SX600-G

Cooling Custom water-cooling
loop, featuring Bitspower CPU
and GPU waterblocks, and two
240mm radiators



were issues, and the biggest one was print quality.

I already knew that the print quality from a lot of consumer-grade 3D printers wasn't of the highest calibre; what I didn't know was how poorly they would handle such large parts. Some of the largest pieces of this project barely fit on some consumer grade printers. The first parts I printed had numerous errors and the quality was less than stellar. My biggest complaint was the dimensional accuracy; some of the pieces' dimensions were so inaccurate that the panelling I'd cut wouldn't even fit into the correct places. At this point, I started looking for a 3D printing service with a different printer to make these parts for me.

CPC: What tools and machinery did you use?

Christian: I started by making the 3D model on the computer. I used a



piece of software called SolidWorks to design all the parts, fit them together and make sure the whole model would work. After the modelling was finished, I moved on to actually making the case. The two main pieces of machinery I needed to use were a laser cutter to cut all the panelling, and a Fortus 250 3D printer to print the case. All the other work was done using hand tools and elbow grease.

CPC: How long did the build process take?

Christian: The whole project, from initial concept to the final piece, took roughly just over a year to build. I started work on the original design around August-September 2014, and then started reworking in December 2014. I completed the model in a month or so; the longest period of time was spent trying to find someone to 3D print the case, which took three or four months. Once I had it printed, and up and running, I took it to both PDXLAN 26 and QuakeCon 2015. Then, when I had it back at home, I spent a few more months adding the final touches, the last one being the hardline tubing.



CPC: What did you learn from the build process?

Christian: The biggest lesson I learned is to always plan for the unexpected. Even after all my groundwork with 3D modelling and double-checking measurements, I still ran into some issues, with some parts not fitting quite as well as I'd hoped.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?

Christian: While nothing on which I work will ever be called 'perfect', I'm very happy with the end result. A lot of people have been asking me to release the plans online, so they can print their own cases, and I'm tempted to do that in the future. In terms of what I'd do differently if I built it again, there are a number of minor issues that most people wouldn't notice at first glance, mostly because they're out of sight for obvious reasons.

I would fix those issues, and I'd play with some colour options too. I'd also try to find a cheaper way to 3D print parts, because getting this case 3D-printed by a service wasn't cheap. **CPC**

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to www.bit-tech.net and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand out from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.



Mayhems coolant and dyes

VALUE £50 inc VAT /

MANUFACTURER www.mayhems.co.uk



Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

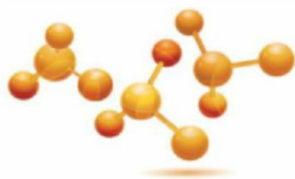
The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-

braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible

motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors.

As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.





Folding@Home

We catch up with top folder PcShedTV

CPC: So who is PcShedTV?

PcShedTV: My name is Sergio Rodrigues, I'm 36 and a dad of two living in Crewe. I'm originally from Madeira, Portugal, but I've lived in the UK for 24 years. I currently work as a contractor for Bentley Motors.

CPC: Why did you start folding?

PcShedTV: I dabbled with folding in 2006 when Nvidia released the GeForce GTX 8800, but my passions back then were water cooling, overclocking and benchmarking in 3DMark. Last September a friend of mine, Richard Downie, started a computer coding course – he needed a PC and asked me to build it. I was a bit rusty and out of touch with PC tech, but I enjoyed building the machine over a period of a few weeks, and that reignited my passion for PC building and gaming.

Over a coffee discussion, Richard suggested I should start a YouTube channel about building PCs, water cooling and overclocking. At the time, I'd been going through a few changes in my life, which gave me a different perspective, so I decided to auction off my beloved Mercedes CL500 and Pc Shed was born. The YouTube channel is non-profit and we do random acts of kindness,



donating PC tech and computer builds once a month to a person who wants to get into PC gaming but can't afford it. I've lost five members of my family in the past four years due to different cancers, and I currently have a member of family with Alzheimer's, so I decided to contribute to medical research with my current PC setup and start folding again properly.

CPC: What excites you most about folding?

PcShedTV: Some people donate to charities, but I chose folding, as I'm directly contributing to several possible cures, which in turn could benefit and help many. Also, my passion for tech gives me a good understanding about how to make the most of older components and put them to good use. I'm very competitive and, having seen other team members' points-per-day (PPD) contributions, I set myself a target to be in the top 100 contributors within 31 days. I achieved it and Pc Shed is currently in 59th position. What's exciting for me is experimenting with different PC components I've acquired over time to try to maximise my ppd.

CPC: What's your folding setup?

PcShedTV: I currently have two PCs folding 24/7 with the Windows desktop client and the web browser client – an air-cooled Core i7-4790K overclocked to 4.6GHz with a Gigabyte GeForce GTX 980 Ti, and a water-cooled Core i7-5960X overclocked to 4.1GHz with a pair of Asus GTX Titan X cards. Richard also folds now and again, but he's

paranoid that his PC is going to go up in smoke while folding. I'm always looking for bargains on eBay and have acquired three HP Z600 servers and one HP Z800 server using Xeon 5500 and 5600 series CPUs. These servers are currently being stripped and modified to become 24/7 folding rigs with PCI-E risers to hold four GPUs each. I'm also building a folding rig with an EVGA SR2 X58 motherboard, which can actually overclock a Xeon CPU – I'll be using a water-cooled Xeon X5690 and adding seven GPUs to it.

CPC: Do you intend to keep up your current production level?

PcShedTV: The plan is not only to maintain my PPD, but also to increase it. I'm aiming for my PPD to hit three million by the end of February and four million by the end of March.

CPC: Any tips for team members?

PcShedTV: The Custom PC & bit-tech folding Team is currently in eighth position with 9,589 members, but only a few hundred of them are contributing. If you're a member and have folded in the past, fire up that PC and get folding again – we'll be overtaking TSC! Russia Team and taking 7th place soon!

WHAT IS FOLDING?

Folding@home uses spare CPU and GPU processing cycles for medical research. You can download the client from <http://folding.stanford.edu> and our team ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding on the www.bit-tech.net forums.

STATS

Team rank 31

World rank 1,234

Score 110,777,529

Work units 12,521

Daily points average 3,224,103

MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE	USERNAME	POINTS MILESTONE
AMDftw!	20000	CJTheBrave	600000	robgsxrk4	5000000	Little_Willie	40000000
ewink20	20000	FREE_WORLD	600000	scoobyzilla	5000000	PcShedTV	40000000
Valkyre	20000	Mike1419	600000	RaistlinRTCW	6000000	Portchylad	60000000
Matt_Livemore	40000	dixy999	700000	SMauri	6000000	madmatt1980	70000000
AJJackson1	50000	Chris_Maliepaard	800000	kcanti	7000000	Andy_J	80000000
thecrazyeyes	80000	ChristianEatsCats	800000	kornvdd	7000000	daxchaos	80000000
Fersigo	90000	ligmon	900000	anfortis	8000000	Tattysnuc	80000000
For_Those_We_lost	100000	Bob_D	1000000	arcitech1	10000000	Cmaxx	90000000
Bocs_o_lyffantod	200000	grozzie	1000000	Liam266	10000000	Dickie	200000000
Craig_Morris	200000	markf0wle	1000000	techknowledgey	10000000	piers_newbold	800000000
pig_farmer_uk	200000	p1ngu_666	1000000	andboo1	20000000	HHComputers	1000000000
Reaperman	200000	PatStar	1000000	SirBenjaminNunn	30000000	Slavcho	200000000
BenScoobert	300000	Lethaertes	2000000				
crazeey	300000	slayer200230	2000000				
desrtbaker	300000	smiler	3000000				
john251282	300000	weebob	4000000				
CTHW	400000	andysroms.com	5000000				
Ayeska	500000	Damien_Tanner	5000000				
PeteUKLancs	500000	Ganey	5000000				

THE NEXT OVERTAKE

WORLD RANK	TEAM NAME	POINTS	DAILY POINTS AVERAGE	TIME UNTIL OVERTAKE
7	TSCI Russia	22,408,995,049	23,673,451	4 weeks
8	Custom PC & bit-tech	22,187,225,428	31,632,905	0
12	LinusTechTips_Team	12,620,130,501	35,663,680	6.5 years

TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Nelio	2,529,849,591	170,624
2	DocJonz	1,823,037,611	186,823
3	HHComputers	1,070,174,637	39,718
4	coolamasta	865,019,623	180,402
5	piers_newbold	814,857,628	50,381
6	Scorpuk	778,522,935	32,525
7	PC_Rich	575,282,287	83,528
8	StreetSam	571,113,589	90,231
9	johnim	487,807,815	82,400
10	Lordsoth	480,939,346	100,097
11	Dave_Goodchild	465,923,185	119,946
12	Slavcho	441,862,585	37,357
13	The_M2B	373,571,092	62,053
14	Laguna2012	372,980,829	26,083
15	Desertbaker	287,550,389	21,152
16	phoenicis	250,044,587	95,660
17	KevinWright	247,562,611	31,858
18	TheFlipside	229,010,716	23,729
19	Dickie	220,137,951	10,964
20	apeman556	218,782,967	30,412

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	HHComputers	5,860,403	1,069,477,020
2	DocJonz	3,981,597	1,822,659,556
3	PcShedTV	2,082,561	45,870,346
4	piers_newbold	1,480,740	814,706,300
5	Nelio	1,391,348	2,529,760,509
6	Scorpuk	1,286,303	778,316,349
7	Lordsoth	1,166,343	480,793,776
8	Dickie	1,065,262	220,030,542
9	coolamasta	948,783	864,889,658
10	daxchaos	936,658	84,577,209
11	PC_Rich	920,978	575,177,580
12	Slavcho	632,939	441,789,037
13	KevinWright	604,515	247,492,853
14	madmatt1980	587,557	74,870,578
15	Laguna2012	571,604	372,942,954
16	BeezaBob	536,116	115,239,625
17	apeman556	495,261	218,604,189
18	Desertbaker	443,304	287,510,061
19	Roveel	401,329	175,759,547
20	The_M2B	383,882	373,536,198



JAMES GORBOLD / HARDWARE ACCELERATED

I'VE WAITED 20 YEARS FOR DECENT VR

And it's finally here, argues James Gorbald

Back when I was at university studying politics, my flatmates had a nickname for me – 'VR James' – earned because I spent so much time playing and making levels for Doom and other games. Technology was improving so markedly at that point that it truly didn't seem long until virtual reality (VR) gaming would take over from viewing games on a monitor.

In reality, it's taken more than 20 years to get usable and enjoyable VR. The great experience now possible is no doubt due to the hard work of the clever folks at HTC and Oculus, but we also shouldn't underestimate the importance of the development of powerful GPUs, with even today's sub-£250 graphics cards struggling to hit a smooth frame rate in VR.

Another important trend to consider is that the PC is currently in the middle of a gaming renaissance – there are loads of top new games in the works, plenty of PC game developers and publishers are making good money, and PC gaming hardware sales are on the increase. As a result, developers and publishers alike are far keener on developing VR games for the PC, which in turn will give the PC yet another edge over the aging consoles. Plus, with another Doom game release just a few months away, the potential for me to finally battle demons in the way my alcohol-fuelled student brain feverishly imagined is truly thrilling.

VR is about far more than gaming, though, especially if you have an HTC Vive. Thanks to its controllers, motion sensors and front-facing camera, the Vive could be an unparalleled tool for training, education, exploration and, of course, the adult entertainment industry. As somebody who is spectacularly

inept at DIY, I'm really looking forward to the commercial version of the Vive, as its front-facing camera could allow some amazing alternate reality tutorials, showing me how to do the basic plumbing and decorating tasks that my brain can't accomplish.

Probably the most common question I get asked by people who haven't been lucky enough to spend a decent amount of time with the Vive or the Rift (there are certain perks of working for Scan) is: 'Will VR flop like 3D?' It's a valid question. After all, Nvidia did make a big push towards 3D gaming on the PC for a while. However, VR fundamentally changes how you experience

the virtual world, immersing you fully in a way that's impossible with a monitor – it uses stereoscopic 3D, but in a way that makes much more sense than having your eyes tricked by a flat screen in front of you. This time around, Nvidia is in a much stronger market position too, and has been joined by other companies such as AMD and Valve to

push VR as a viable alternative to a monitor.

Speaking of products, the first two true VR headsets are now both available for pre-order. The HTC Vive costs \$799 (£574) with delivery expected in April, while the Oculus Rift costs \$599 (£430), but won't be delivered until July. Although they're more expensive than some pundits predicted, the pricing doesn't seem extreme to me, especially when you consider the price of a high-end gaming monitor such as the awesome 34in Asus PG348Q. Plus, like any new technology, the price will come down once production increases and the R&D costs have been recovered. Just make sure you have a PC that's powerful enough – on VR, you can't simply dial down the resolution if you aren't getting a smooth frame rate. **EPC**

VR fundamentally changes how you experience the virtual world

James Gorbald has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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